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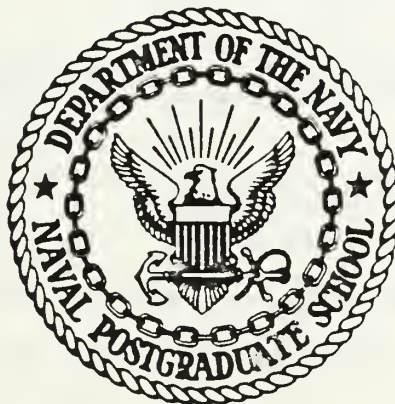
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NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

SUPPORT EQUIPMENT MANAGEMENT IN THE
F/A-18 PROGRAM

by

Kenneth S. Graeser

December 1986

Thesis Advisor:

J.F. McClain

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Support Equipment Management in the F/A-18 Program

by

Kenneth S. Graeser
Lieutenant, United States Navy
B.S., Middle Tennessee State University, 1977

Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

Since the early 1960s, the Navy has witnessed the introduction of aircraft of increasing technical complexity. While possessing superior tactical abilities as an outgrowth of this technical complexity, these aircraft have displayed an increasing need for specialized repair capabilities. As a result, the number and types of support equipment (SE) required to maintain them have risen dramatically. This thesis examines the policies and methods for support equipment acquisition and management as established by the Naval Air Systems Command. The primary focus is on the integration of these procedures with the program management structure of specific aircraft programs. The research examines in-depth several innovations to the support equipment planning and management process instituted with the F/A-18 program and evaluates them for effectiveness.

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I. INTRODUCTION

A. PURPOSE

Since the early 1960s, the Navy has witnessed the introduction of aircraft of increasing technical complexity. While possessing superior tactical abilities as an outgrowth of this technical complexity, these aircraft have displayed an increasing need for specialized repair capabilities. As a result, the number and types of support equipment (SE) required to maintain them have risen dramatically. Total Naval Air Systems Command (NAVAIR) support equipment fiscal requirements for procurement for FY 86 were \$935 million and for FY 87 are budgeted at \$857 million. Although these figures represent a downward trend, the support equipment budget remains a significant item in any major weapon system program. [Ref. 1]

The increased sophistication of modern aircraft has increased the cost and complexity of all support areas. Due to cost overruns and poor operational availability on several weapon system programs, an increased effort was necessary to give support a more visible role in the acquisition process. The Department of Defense solution to this situation was the concept known as Integrated Logistic Support (ILS). (Appendix A provides an overview of the DOD Integrated Logistic Support Process.) Support equipment is

considered one of the ten logistic elements which are to be integrated and coordinated by the aircraft Program Management Office (PMO). It was also recognized that the individual aircraft/system program management efforts did not possess the broad perspective necessary to match the resources required with demands in the support equipment area. Additionally, a preoccupation with airborne systems and components within the PMO resulted in insufficient emphasis being placed on the necessity for concurrent development, procurement, and availability of support equipment with the aircraft system. These concepts are the primary factors influencing the state of program support equipment management as it exists today.

Aviation support equipment is that equipment which provides maintenance support directly to an aircraft weapon system or an uninstalled aircraft component undergoing test or repair. Support equipment can be divided into two broad categories--peculiar and common support equipment. Common support equipment is an item of support equipment which has application to, and is used in support of, more than one system or aircraft. Of particular importance is peculiar support equipment (PSE). PSE is that equipment which has specific application to only one type of weapon system. Classifying a piece of support equipment as PSE does not necessarily mean that it is unique to one specific aircraft, but rather that it is unique to one specific system that may

be used on several different types of aircraft. PSE may include both hardware and software, particularly in light of the emphasis on automated testing in avionics maintenance. In most cases, PSE must be designed and developed in conjunction with the end article. The most significant increases in both requirements and funding for support equipment in recent years have been for peculiar support equipment. PSE is a significant part of the acquisition cost of any aircraft weapon system. On the F/A-18 program, PSE spending currently represents approximately 10 percent of total program spending [Ref. 2].

The intent of this thesis is to examine the policies and methods for support equipment acquisition and management as established by the Naval Air Systems Command. The primary focus will be on the integration of these procedures with the program management structure of specific aircraft programs. The research will examine in-depth several innovations to the support equipment planning and management process instituted with the F/A-18 program and evaluate them for effectiveness.

B. APPROACH

The research scheme for this thesis consisted of a comprehensive review of existing directives, instructions, other written material, and interviews with personnel of the functional divisions at the Naval Air Systems Command Headquarters and the F/A-18 Program Management Office. This

thesis concentrated on the specific interactions of the Navy participants in the support equipment management process and did not examine the operating methods or management structures of typical weapon system prime or support equipment contractors. The thesis assumes a basic knowledge of the DOD Integrated Logistic Support process. Appendix A provides a comprehensive overview of this concept.

C. LIMITATIONS

The area of contractual strategies to incentivize contractor performance holds great potential for improving SE schedule performance. However, due to the numerous combinations of incentive strategies possible and the primary focus of this thesis on program management techniques, the arena of specific strategies to incentivize contracts was deemed not within the scope of this study.

D. ORGANIZATION

This thesis is divided into an introduction, three development chapters and a final chapter of conclusions and recommendations. Chapter II provides an overview of the organizational structure and relationships of support equipment planning and management. Chapter III addresses the support equipment management innovations utilized in the F/A-18 program. Chapter IV evaluates these techniques for effectiveness.

Two appendices are also included. Appendix A provides an overview of the ILS process. Appendix B provides a comprehensive list of acronyms used in this study. Appendix C presents a summary overview of the acquisition process.

II. SUPPORT EQUIPMENT ORGANIZATION

The responsibility for the development and procurement of support equipment for Naval Aviation is vested in the Commander, Naval Air Systems Command (NAVAIRSYSCOM) [Ref. 3:p. 3]. Under his direction, these activities are conducted by the functional divisions of NAVAIRSYSCOM headquarters and various field activities. The support equipment effort for specific aircraft programs is accomplished under the direction of the Program Manager--Air (PMA) as designated by the Commander, NAVAIRSYSCOM. The PMA pursues this tasking through a small, dedicated staff in the Program Management Office and the assistance of representatives of NAVAIR functional divisions assigned to him through a matrix organization concept. This section will provide an overview of the NAVAIR functional organization, the functional organization of the Program Management Office, and the matrix organization through which both interact.

A. NAVAIR FUNCTIONAL ORGANIZATION

Figure 1 presents the organizational structure of the NAVAIR headquarters for support equipment. The organization follows the classic form of functional organization in that all those engaged in similar activities are brought together in one group. The functional groups are each further divided into functional divisions which emphasize a more

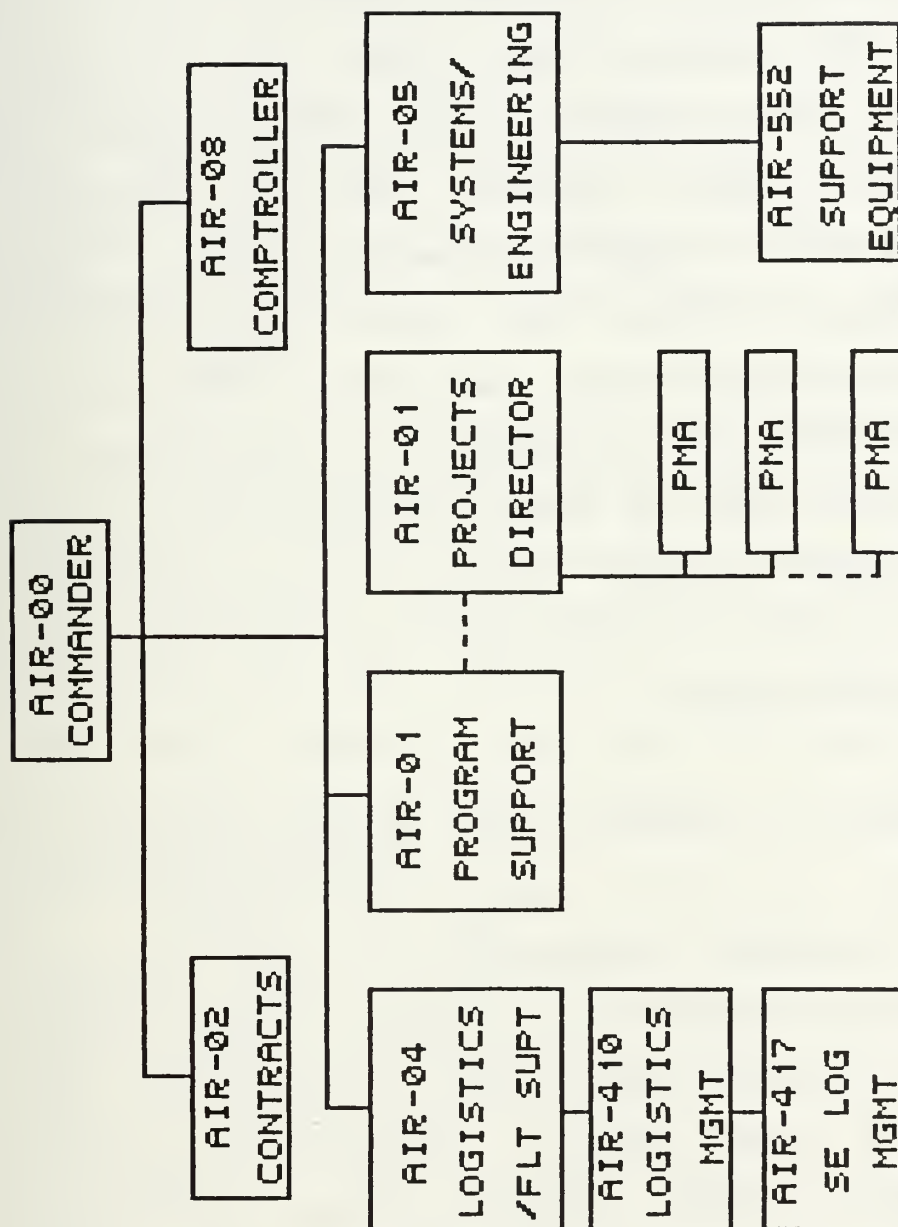


Figure 1. NAVAIR Headquarters Organization for Support Equipment

narrow range of skills and responsibilities. Routine workload is processed functionally through the groups.

As can be seen from Figure 1, the support equipment effort involves a number of the NAVAIR functional groups in some manner. The principal participants in the design, development, procurement, deployment and logistic support of SE are AIR-417, Support Equipment Logistics Management Division and AIR-552, Support Equipment Division. These divisions are organized under AIR-4, Logistics/Fleet Support and AIR-05, Systems/Engineering, respectively. The program management offices which are responsible for the integration of SE requirements into the overall management of a weapon system are organized under AIR-01, Projects Director. Projects Director is an additional duty for the Deputy Commander--Program Support.

1. AIR-01

The Deputy Commander for Program Support is responsible for providing command-wide direction and coordination of planning, programming, priorities determination, and management information to foster a cohesive operation in meeting overall command goals and objectives [Ref. 4:p. 01-3]. As stated above, an additional duty of the Deputy Commander, Program Support is that of Projects Director. It is in this capacity that AIR-01 is responsible for developing, monitoring, and coordinating the overall activities of assigned major weapon system programs [Ref.

4]. The organization of AIR-01, Projects Director is further divided into Weapons Programs, Anti-Submarine Warfare Programs and Tactical Aircraft Programs under the auspices of Program Directors. It is within these categories that the various weapon system PMOs are organized according to their intended mission. All Program Managers-Air (PMAs) are accountable to the Commander, NAVAIRSYSCOM through their respective Program Director and the Deputy Commander and Projects Director (AIR-01). [Ref. 5:p. 2]

2. AIR-04

The Assistant Commander for Logistics/Fleet Support has the primary responsibility of developing, executing, and managing all elements of integrated logistic support for each aeronautical weapon system developed or procured for U.S. Navy use [Ref. 4:p. 04-1]. Of primary importance in the support equipment arena are the functional divisions AIR-410, Logistics Management and AIR-417, Support Equipment Logistics Management.

AIR-410 is tasked with accomplishing overall ILS management on all NAVAIR designated weapon system programs. This includes both existing and proposed aircraft. In this capacity, AIR-410 plays a pivotal role in the selection and assignment of the Assistant Program Manager-Logistics (APML). As will be discussed in a later section, the APML is responsible for the coordination and integration of the

specific program's total logistic support efforts including maintenance engineering and SE acquisition. [Ref. 6:p. 30]

AIR-417, as its title suggests, is the division of AIR-04 dedicated solely to support equipment. The objective of this division is to develop plans and policies for timely, effective, and economical life cycle integrated logistic support for all support equipment. Areas of emphasis include SE maintenance engineering, inventory management, supply support and managing the support equipment rework program. This division is specifically tasked with accomplishing ILS management on SE for aircraft, aircraft equipment, and support equipment for NAVAIR designated program offices (PMOs). [Ref. 4:p. 417-3]

3. AIR-05

Operational planning and execution of approved programs from concept exploration through delivery is the responsibility of the Assistant Commander for Systems and Engineering. Contained within this sphere of responsibility is the development and engineering of support systems. These activities for SE are executed within the AIR-05 group by the Support Equipment Division, AIR-552. The Support Equipment Division is the NAVAIR focal point for SE and has the ultimate responsibility for ensuring that suitable SE is developed and made available to the fleet. [Ref. 4:p. 552-3]

The Director of the Support Equipment Division (AIR-552) assumes a significant role in the support equipment development, procurement, and management process. Since June, 1967 he has been chartered as the Program Manager for Support Equipment [Ref. 3:p. 2]. This action took place in response to the increasing numbers of complex weapons systems in operation and under development. Although the Integrated Logistics Support concept had been adopted throughout DOD earlier in the decade, increasingly complex weapon systems generated a demand for more elaborate, costly, and varied types of SE. Support equipment was assuming an increasingly important and costly role in the development and introduction of aeronautical weapons systems. Clearly, a concentrated effort was required to reduce the quantity and variety of SE being introduced to the fleet. A NAVAIR determination was made that a centrally-managed and coordinated design, development, and procurement program for new SE items was necessary. Additionally, this effort was to focus primarily on multi-purpose equipment rather than specialized or peculiar equipment and be pursued under the program management concept. [Ref. 3:p. 2]

Under the terms of his charter, the Program Manager for Support Equipment (PM-SE) is tasked with overall direction and control of the support equipment program. The PM-SE has the same authority and responsibility for SE as

the PMA has for his weapon system. In this capacity he reports directly to the Commander, NAVAIRSYSCOM. Program Managers are specifically directed to work closely with the PM-SE to ensure that program support equipment requirements, plans, and funds are made available in a timely manner. The role of AIR-552 was further strengthened when he was later designated System Program Manager for Support Equipment (SPM-SE). In accordance with NAVAIR policy, System Program Managers are designated for command-wide management of selected commodity area programs which require intensified management and centralized direction [Ref. 5:p. 2]. With this action, support equipment was elevated functionally to a level commensurate with that of the Program Management Office. This arrangement ensures the review, with the PMA and APML, of trade-offs among support elements which may be detrimental to support equipment. Examples of such trade-offs include equitable sharing of general budget reductions and transfer of funds between elements to cover an unanticipated shortfall.

4. NAVAIR Field Support Activities

The NAVAIR field support activities are organized functionally under AIR-04 and AIR-42, Navy Ranges and Field Activity. The field support activities are directed to provide technical support to the SPM-SE in the areas of engineering, logistics, test and evaluation, and production. Additionally, the PMA possesses the authority to direct the

assignment of tasks to field activities through the appropriate NAVAIR functional element [Ref. 5:p. 6]. The field support activities primarily involved with support equipment are the Naval Avionics Center (NAC), Naval Air Engineering Center (NAEC), and the Pacific Missile Test Center (PMTC).

B. PROGRAM MANAGEMENT OFFICE

It is a fundamental Department of Defense policy that all major weapon system acquisitions will be directed by a specifically responsible manager under the concept of program management [Ref. 7:p. 1]. Within NAVAIRSYSCOM, the single, central executive responsible for the successful completion of a designated program is the Program Manager-Air (PMA). Upon appointment the PMA is issued a tailored charter which lists the mission, authority and responsibilities of the program. He receives his authority from and is ultimately accountable to the Commander, NAVAIRSYSCOM. Accordingly, the PMA is authorized direct access to the Commander, from whom he receives broad policy guidance. The PMA's tenure is to be of sufficient length to provide continuity and personal accountability. Current NAVAIR policy for a PMA assignment is four years [Ref. 8]. The PMA billet is equivalent to that of a major command and is normally filled by a Navy captain or Marine Corps colonel.

Program management within NAVAIR is based on the matrix organization concept. Accordingly, the staff of the Program Management Office (PMO) is small relative to the entire team

working on the program. Sections for Business/Finance, Foreign Military Sales, Engineering and Advanced Development, and Fleet Readiness form the core of the typical PMO. Figure 2 illustrates the essential elements of the current F/A-18 program office. The sections within the PMO conduct liaison and act as contact points for their counterparts in the functional divisions. Of prime importance, from the perspective of support equipment, is the Fleet Readiness section. This section serves as the PMO interface between the fleet user and the logistics community in AIR-04. In this way, the Fleet Readiness section can serve as a clearinghouse for fleet problems and help direct the program logistics efforts [Ref. 9]. Although the Fleet Readiness section deals primarily with logistic support and logistics concerns, it is important to stress that it does not include the logistics specialists for the program. The APML in AIR-410 remains the primary figure responsible for the identification, development, and management of logistic support for the program.

C. NAVAIR PROGRAM MATRIX STRUCTURE

In order to solve complex problems, such as those found in the development and support of modern weapon systems, a multidisciplinary approach is required. Many organizations have found superimposition of program management on the existing organizational structure to be advantageous. The

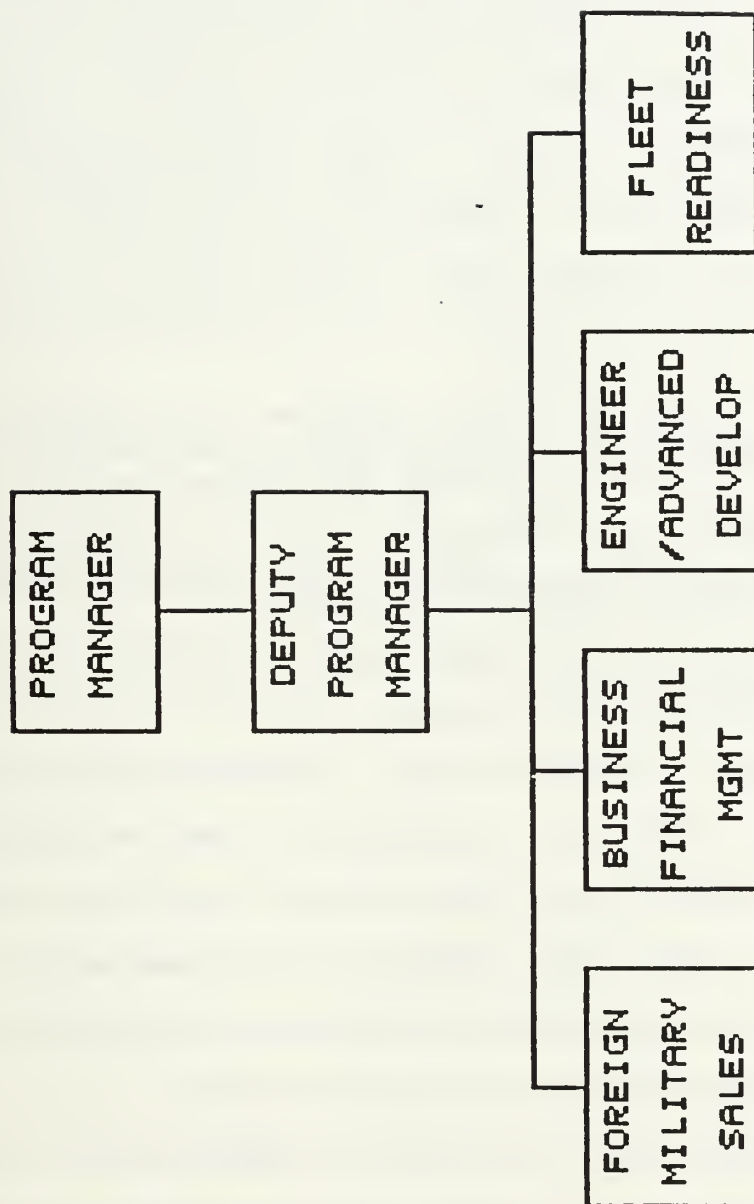


Figure 2. F/A-18 Program Management Office Organization

two types of program management organization most widely used today are the pure program and matrix structures.

The pure program organizational structure is built on the concept of an independent entity. Personnel required for the program are assigned solely to the PMO and are not shared with any functional division. They are under the direct and immediate control of the Program Manager (PM). In most cases, the staff is physically located with or near the PM. Primary advantages of the pure program structure include: [Ref. 10:pp. 53-54]

- Reduction in the PM effort required to coordinate the various elements of the program. The PM has ready access to and complete control of program personnel.
- Fewer organizational barriers, such as those between program and functional staffs, can improve communication and enhance information transfer.
- Physical proximity and PM direct control facilitate faster response times.

The pure program structure is the primary organizational structure used by the U.S. Air Force for the management of weapon system acquisition [Ref. 11:p. 2]. The foremost disadvantage of the pure program organization is the considerable cost required to establish and maintain the structure, both in terms of money and personnel.

A primary advantage of the matrix organization, due to the sharing of resources, is its cost effectiveness. Other advantages include: [Ref. 10:pp. 56-57]

- Retention of the technical specialists within the functional divisions vice the program office permits increased professional interaction among disciplines.

"Lessons learned" on a specific program can be evaluated for use on many programs.

- Program support is provided by offices with a long-term interest and commitment to their speciality and the specific program. This is contrasted to the temporary nature of the pure program organization.

While the matrix structure presents many advantages, the complexity of the alignment and its working relationships can be cumbersome and difficult to implement. Additionally, there is a high potential for conflict between program and functional managers, who may each possess a parochial point of view.

NAVAIRSYSCOM program management is conducted within the framework of the matrix structure. The PMA, with the assistance of his assigned PMO staff, exercises centralized program authority. The program office is supported in this effort by technical specialists within the various functional divisions. The technical specialists remain assigned to their respective divisions, not the program office. Although the PMA exercises the program authority, he is dependent on the managers of the functional divisions to control the technical resources required to meet program objectives. Figure 3 characterizes the general relationships between program management and functional management and their respective orientations under the matrix concept. As can be readily seen, the ability of the PMA and his staff to effectively coordinate and direct the functional divisions is critical to the success of the matrix structure.

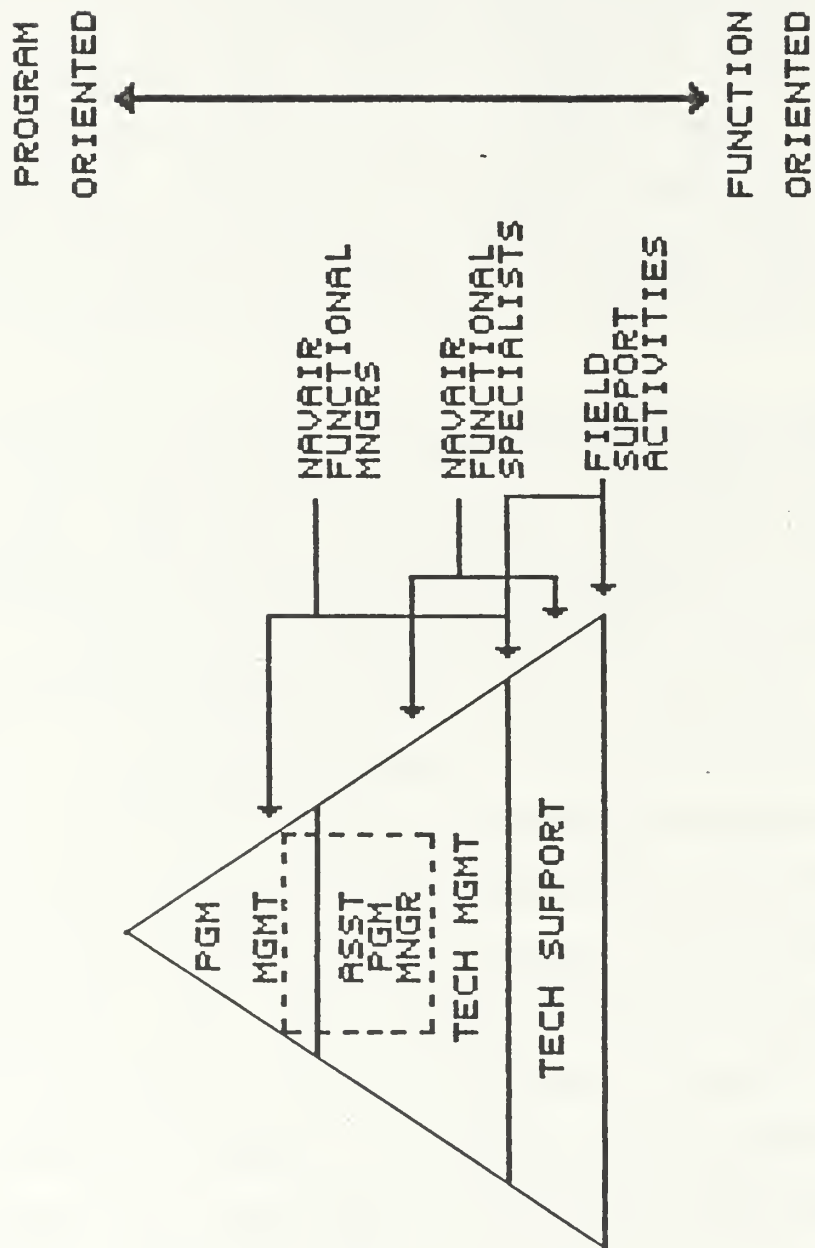


Figure 3. Program/Functional Management Relationships
[Ref. 7:p. 5]

The effectiveness of the PMA is highly dependent on his ability to foster a teamwork approach among the technical specialists in the functional divisions. In this regard, the PMA is aided by Assistant Program Managers (e.g., APML) who are assigned, with the concurrence of the PMA, by each functional group. The APM serves a dual purpose role--representing specific program interests within the functional group and simultaneously representing the functional group to the program. It is through the Assistant Program Managers that the PMA coordinates the support efforts of the functional groups to meet program goals for cost, schedule, performance, and logistics supportability.

1. Support Equipment Management Structure

As mentioned earlier, the increasing cost and low operational availability of weapon systems in the 1970s had served to focus scrutiny on support and logistic functions. The practice of sacrificing program funds intended for support in order to cover unanticipated shortfalls in system performance was widespread. This phenomenon was perhaps no better illustrated than in 1977 when all cost estimates of the F-14 aircraft exceeded original projections while the aircraft was experiencing an operational availability rate of less than 40% [Ref. 6:p. 16]. These events provided the impetus for the enhanced status of support equipment within NAVAIR.

Probably the most significant event serving to increase SE visibility was the designation of the Director, AIR-552, as System Program Manager for Support Equipment (SPM-SE), as stated earlier. The SPM-SE, chartered in the same manner as the Program Manager, is ultimately responsible for coordination and management of all aspects of NAVAIR SE programs [Ref. 3:p. 3]. While the SPM-SE has overall responsibility for SE development and management, his designated representative--the Support Equipment Program Officer (SEPO)--serves as the primary SE interface with the individual program office. The SEPO is responsible for both the identification and procurement of peculiar support equipment and the identification of common support equipment for the weapon system. In this endeavor, the SEPO is supported by AIR-552 designated Acquisition Managers who are responsible for the acquisition of support equipment within a specific commodity area (e.g., Aircraft Starting Equipment).

Most Acquisition Managers support more than one program when commonality of equipment exists within a commodity area. While all PSE is procured by the Acquisition Managers in AIR-552, the majority of CSE (that which has reached a mature design stage and is established as an inventory item) is procured by the Aviation Supply Office (ASO) in Philadelphia, PA. Common support equipment requirements for a specific program are passed to ASO by the

SEPO. A minority of CSE items, those of developing design, are procured by the Acquisition Managers in AIR-552. [Ref. 12]

AIR-417 completes the assembly of NAVAIR headquarters participants in the SE matrix structure. Charged with the ILS management of support equipment, the Director, Support Equipment Logistics Division appoints a Logistics Manager-Support Equipment (LM-SE). As SE requirements are identified for the program, the SEPO feeds this information to the LM-SE in AIR-417. This provides AIR-417 the opportunity to analyze and plan the integrated logistic support for the SE itself prior to acquisition. There is also frequent interaction between the LM-SE and the Acquisition Managers in AIR-552 to coordinate ILS elements for support equipment.

Technical support is provided to both the SEPO and the LM-SE by the Naval Air Engineering Center, a NAVAIR field support activity. Figure 4 presents the essential elements of the NAVAIR support equipment matrix as it exists for the F/A-18 program.

2. Integrated Logistic Support Matrix

Integrated logistic support analysis is performed for each end item of the weapon system. This process is accomplished by the Integrated Logistic Support Management Team (ILSMT). The ILSMT determines the quantitative logistic support requirements to be included in program

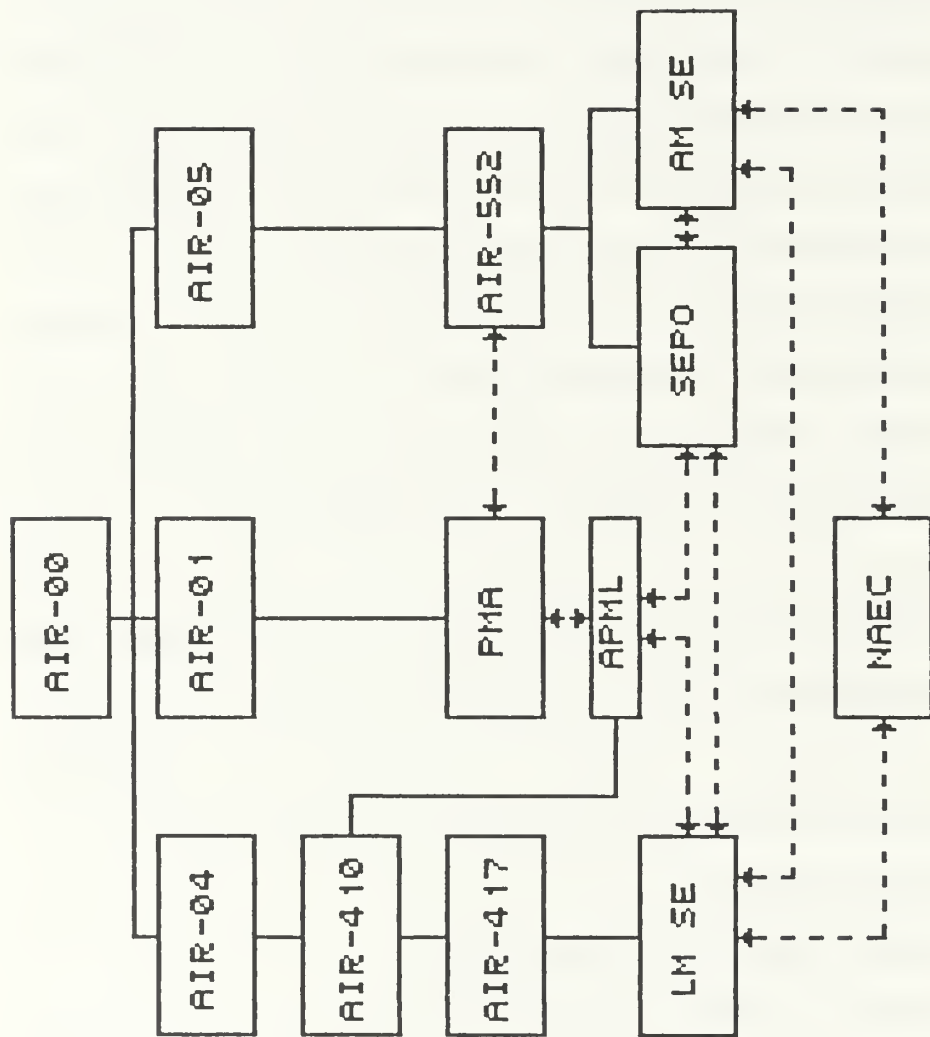


Figure 4. NAVAIR Support Equipment Matrix Organization

— Organizational Lines
 ---- Information Flow

management and decision making documentation. These logistic requirements are determined by each element of support (e.g., publications, personnel, support equipment). In the context of support equipment, there are two ILSMT's that must be considered--one for the support equipment element itself and one for the weapons system as a whole.

The ILSMT for the support equipment itself is headed up by AIR-417. As the designated ILS Manager for Support Equipment, AIR-417 consolidates all required logistic support for the support equipment that is identified for the program by the SEPO (from AIR-552). This information then flows to the PMA via the APML through the weapons system ILSMT.

The ILSMT for the weapons system is chaired by the APML. It is through the vehicle of the ILSMT that the APML is able to coordinate and integrate all logistic elements toward the support of the weapons system itself. The team consists predominately of representatives of the various functional divisions within AIR-04, supporting each logistic element. The logistic element of support equipment is represented on the weapons system ILSMT by a group headed by the Logistic Element Manager for Support Equipment (LEM-SE). Due to the similarity of tasks, the LEM-SE is normally the designated SEPO from AIR-552. In this way, the analysis and planning of the support equipment ILSMT can be blended with the overall logistics planning for the weapons system.

D. SUMMARY

This chapter has provided an overview of the principal participants involved in coordinating support equipment requirements for NAVAIR weapon system programs. NAVAIR program management is conducted through the matrix organization structure. The primary functional divisions with regard to support equipment are the Support Equipment Division (AIR-552), and the Support Equipment Logistics Division (AIR-417). The Director, Support Equipment Division is the designated NAVAIR System Program Manager for SE (SPM-SE). In this capacity, he is responsible for the overall direction and management of all NAVAIR support equipment programs. The weapon system program itself is headed by the Program Manager-Air (PMA), specifically responsible for the successful completion of the program. The PMA manages the program through the small staff of the Program Management Office and designated representatives of the functional divisions. Support equipment requirements for the program are executed by the Support Equipment Program Officer (SEPO), the designated representative of AIR-552 assigned to the program. Coordination of all logistics elements for the program, including support equipment, is the responsibility of the Assistant Program Manager for Logistics (APML).

III. THE F/A-18 APPROACH TO ILS/SUPPORT EQUIPMENT MANAGEMENT

A. INTRODUCTION

The complex weapons systems introduced in the late 1960s and early 1970s had provided the Navy with an impressive potential tactical advantage. However, this potential had been severely constrained by an inability to sustain a high level of operational readiness in the fleet environment. The earlier mentioned shortfalls with the F-14 program had drawn Congressional attention to Navy acquisition procedures and added a significant impetus to the F/A-18 program. The F/A-18 was a direct result of Congressional cuts in F-14 procurement and the Navy's desire to procure a less expensive augment to the F-14. Implicit in this desire were the design goals of commonality, multi-mission capability, and high reliability and maintainability. [Ref. 6:p. 16]

Although the ILS discipline and methodology had been integrated into DOD acquisition procedures since 1964, the expected benefits of this methodology had not been fully realized. The low readiness rates and inadequate support efforts affecting aircraft programs of this era were the same problems that had existed for many years. This situation was exacerbated by the increasingly complex avionics systems on these aircraft and the requirement for sophisticated support and test equipment. Clearly, an acquisition

strategy which focused primarily on performance and subordinated the support effort was no longer practical.

Historically, the design and procurement of aviation weapon systems had proceeded from a performance perspective. Program Managers, especially those on tactical aircraft programs, were typically from the performance-oriented fighter and attack communities. While superior aircraft performance is a necessary and desirable goal, the pursuit of weapon system performance at the expense of other programs goals typically resulted in minimal early planning for support. Additionally, any funding shortfalls that arose in the development of the aircraft were normally resolved by a cut in funding for some or all elements of support. A common philosophy espoused was that which said if the aircraft meets performance requirements, money to solve support deficiencies would be made available [Ref. 6:p. 45]. The F/A-18 was to be the first aircraft acquisition program which would include actual compromises between performance and supportability goals from the earliest planning stages. Also, it would be the first program to incentivize support as well as performance. [Ref. 13]

An additional factor influencing the formulation of the F/A-18 acquisition philosophy was the SPM-SE chartered requirement to reduce the proliferation of PSE [Ref. 3:p. 2]. This requirement was to be pursued through the concept of maximum standardization of required F/A-18 SE across the

current support equipment inventory. A crucial aspect of this is the identification of support equipment requirements as early as possible in the weapon system development. This is the most effective means by which the design of the weapon system and its components can be influenced toward compatibility with existing support and test equipment.

The prime objective of the F/A-18 ILS program is to design, develop, and deliver a logistic support system that enables the fleet user to achieve an operational readiness rate of 85% [Ref. 14:p. 15]. This program is an example of one which incorporates a number of innovations in support development, beginning with the early stages of the program. Some of the methods represent an improvement on or a formal recognition of beneficial practices developed on earlier programs. This chapter identifies the supportability innovations that were instituted with the F/A-18 program with respect to support equipment and the related PMO/functional matrix interface. While some of the innovations do not apply directly to the subject of support equipment, their affect on the integrated support system indirectly influences SE. The primary source for the material in this chapter is a study conducted by Rodney Donald Beran and Paul Roger Decker at the Naval Postgraduate School in 1977 [Ref. 6], during the early stages of the F/A-18 program. In the following chapter, the long term effectiveness of these

innovations is evaluated based on interviews of key personnel currently involved with the program.

B. WEAPON SYSTEM OVERVIEW

The F/A-18 Hornet strike fighter is a multi-mission aircraft designed for aircraft carrier operations. The twin-engine aircraft was developed with the intention of replacing the F-4 and the A-7 aircraft in the Navy and Marine Corps inventory. The F/A-18 will perform fighter and light attack missions such as strike escort, fleet air defense, interdiction, and close air support. Though not currently a part of the program, original plans included the development of a photo/reconnaissance version of the Hornet to replace the RF-4 and RF-8 aircraft.

The F/A-18 is designed and produced to permit two configurations--fighter and attack. The two versions are identical except for external equipment or ordnance peculiar to their particular mission.

The F/A-18 Full Scale Development Phase began in early 1976, and the first flight was made in November, 1978 (see Appendix C for a summary overview of the typical weapon system acquisition process). The initial Navy F/A-18 squadron was commissioned on November 13, 1980 at the Lemoore Naval Air Station and received its first aircraft in February, 1981. This was the Fleet Readiness Squadron, responsible for training Navy and Marine Corps fighter and attack pilots and also maintenance personnel of both

branches. Initial Operational Capability was scheduled for December, 1982 with the Marine Corps and the first F/A-18 carrier deployment was scheduled for 1985.

The McDonnell Douglas Corporation of St. Louis, Missouri is the airframe prime contractor. McDonnell Douglas has overall weapon system performance and technical management responsibility. Principal subcontractors include the Northrop Corporation, producing the major fuselage components and Hughes Aircraft Company, producing the radar system for the aircraft. The General Electric Company developed and produces the aircraft's F404 turbofan engines.

C. ADVANCE PLANNING FOR SUPPORT

A review of the experience associated with many of the systems in use today will indicate that the resultant output is highly influenced by the planning and design decisions made during the early phases of the system acquisition cycle [Ref. 15:p. 87]. Because the elements of logistics can significantly influence life cycle costs and effectiveness, it is necessary that support concerns be addressed from the beginning of the program. While this principle would seem obvious given today's knowledge, it apparently was of marginal concern in programs prior to the F/A-18. A quote from the APML during the initial stages of the program is indicative of the F/A-18 commitment to support as well as performance: [Ref. 6:p. 35]

It seems in past programs logistics received little PMA attention until fleet introduction. The major area of concern was the design and performance of the aircraft. This trend has been reversed in the F/A-18 program. PMA-265 is keenly aware of the importance of detailed planning and integration of logistics from the beginning of the program.

In the area of support equipment, AIR-552 was involved beginning with the Full Scale Development contract pre-award period. The Support Equipment Division screened the procurement package presented to contractors for inclusion of appropriate Military Standards (MIL STDS) and for compatibility with existing Automatic Test Equipment. AIR-552 was also a participant in the subsequent evaluation of proposals submitted by contractors. [Ref. 6:p. 4-4]

Another factor in concert with the theme of early support planning was the timely establishment of the Resident Integrated Logistic Support Detachment (RILSD) at the contractor's facility. This event occurred within 30 days of the award of the Full Scale Development contract. The RILSD is a team of technically qualified Navy personnel who are responsible to the APML. The Detachment's purpose is to: [Ref. 17:pp. 2-9]

1. Provide continuous on-site technical liaison and make recommendations to the contractor's F/A-18 Program Management organization during the initial logistics development.
2. To review, approve as authorized, and make recommendations to NAVAIR concerning contractor deliverables pertinent to the ILS discipline.
3. Perform a monitoring function of the development of the ILS discipline.

The charter of the RILSD specifically addressed support equipment issues. Additionally, the RILSD included for the first time a dedicated support equipment representative from NAEC, the AIR-552 field activity for technical support. A primary emphasis of the SE representative was participation in all phases of design review in order to influence standardization of support equipment requirements.

Further evidence of the commitment to support on the program was the incentive structure of the F/A-18 Full Scale Development contract. The contract, of the Cost Plus Incentive Fee type, contained incentives totalling approximately \$30 million that were split between performance and support [Ref. 6:p. 35]. Incentive awards in the support area were to be based on pre-deployment and post-deployment evaluations of supportability [Ref. 17:p. 10-5]. Due to the inextricable link between adequate and well-functioning support equipment and the supportability of the aircraft, SE would be a prime factor in determining the incentive award. In this case, PSE, which is normally procured from the prime contractor, would be especially significant. For the first time, a portion of the contractor's fee would be determined by how well the peculiar support equipment performed in the fleet. An additional benefit of the post-deployment supportability demonstration, although not related to any incentive award determination, would be valuable feedback on

the suitability of all ILS resources in supporting deployed aircraft.

In reference to selection and design of PSE, a continuing effort was made in the F/A-18 program to prioritize the development of maintenance capabilities (i.e., maintenance plans, training, technical publications, PSE, etc.) within previously determined maintenance levels (organizational (O), intermediate (I), or depot (D)). The prioritization was based on reliability and maintainability predictions that resulted from the weapon system design process. Those components/systems with the lowest mean time between failure (MTBF) were logically expected to compose the majority of maintenance actions. As a result, these items were targeted for the highest priority in development of organic (Navy) maintenance capability. It was felt this practice would have a significant impact on the timing of PSE development and further narrow the focus of the PSE effort in the early stages of the program. [Ref. 6:p. 36]

D. PHASED SUPPORT

The concept of phased support, as utilized in the F/A-18 program, is based on the assumption that full Navy support cannot be attained on a single, specific date. Contractor support, at a cost of approximately \$30 million, was planned to continue until system design had stabilized, support equipment was fully configured for fleet use, and the Navy was capable of performing the requisite maintenance tasks

[Ref. 18:p. 6]. Although the phased support concept would increase total program cost, the opinion in NAVAIR was that it would enable the Navy to achieve and maintain a high level of operational readiness during the aircraft's early deployment years.

Another expected benefit was that phased support would permit the Navy to acquire the necessary skills and material resources to assume maintenance responsibility without degrading operational capability. On programs prior to the F/A-18, the Navy had assumed maintenance and supply support responsibility at a much earlier point in the program. Because these systems were at the very early stages of their operational life, many required design modifications to correct deficiencies not discovered until the systems were exercised in the fleet operational environment. In many instances, the design changes would cause a change in maintenance procedures, publications, or equipment. This condition necessitated a maintenance capability that was in a constant state of flux. The phased support concept shifts the risk of early maintenance and support problems from the Navy to the contractor. Ideally, the weapon system and its support subsystems will be debugged before the Navy assumes responsibility.

The S-3A program introduced the phased support concept in 1972 [Ref. 14:p. 12]. In the case of the S-3A however, the phased support program did not include maintenance

capability, but was restricted to the transition of supply support only. The F/A-18 program utilized the phased support concept for both supply support and maintenance capability. The contractor was also required to demonstrate successful support system operation, with production support equipment in a fleet environment, before the Navy would assume maintenance responsibility. [Ref. 19:p. 38]

In order to facilitate the contractor's support equipment development process and to permit opportunities for SE design to mature, Factory Test Equipment was to be used during contractor flight testing and Navy Initial Operational Test and Evaluation. Prior to the Board of Inspection and Survey (BIS) trials for final acceptance of the aircraft for Naval service, the contractor was required to deliver production SE for the organizational maintenance level. During BIS Navy personnel performed the necessary organizational level maintenance while the contractor performed intermediate and depot level maintenance. [Ref. 6:p. 39]

The F/A-18 phased support concept was based on three assumptions: [Ref. 20:p. 3-2]

1. The transition of the maintenance capability and material support responsibility must be concurrently planned and managed.
2. The rate of maturity of the weapon system design determines when the maintenance plan analysis can be initiated and subsequently, when maintenance resources (e.g., support equipment) can be made available.

3. The detail of design, which dictates system level maintenance requirements, stabilizes earlier than the design detail which dictates component maintenance requirements.

Implicit in these assumptions is the prioritization of maintenance capabilities within the three levels of maintenance (O, I, and D), and therefore support equipment development, based on system design maturity. The assumptions also recognized that the rate of design maturity would vary with the level of design (system versus component). Since system level maintenance would be performed at the "O" level, this latter factor was the basis for the transition of organizational maintenance capability preceding the transition of intermediate and depot level capability. Figure 5 illustrates the proposed timetable for the F/A-18 phased support plan.

E. NARF NORTH ISLAND LOGISTIC SUPPORT TEAM

An integral part of the phased support plan was the creation of the Logistic Support Team at the Naval Air Rework Facility (NARF), North Island, California. This team, consisting primarily of engineering personnel, was established to provide technical support to the APML in managing the ILS elements [Ref. 6:p. 41]. Originally intended to be part of the Resident Integrated Logistic Support Detachment at the contractor's facility, the Logistic Support Team was established at NARF North Island due to a paucity of NAVAIR billets at the McDonnell Douglas plant

	78	79	80	81	82	83	84	85	86
O-LEVEL	CONTRACTOR MAINTENANCE		/		NAVY MAINTENANCE				
I-LEVEL (WRA)	CONTRACTOR MAINTENANCE		/		NAVY MAINTENANCE		NAVY MAINTENANCE		
I-LEVEL (SRA)	CONTRACTOR MAINTENANCE		/		/		NAVY MAINTENANCE		
D-LEVEL	CONTRACTOR MAINTENANCE		/		/		NAVY MAINTENANCE		
SUPPLY SUPPORT	CONTRACTOR ACQUISITION AND MAINTENANCE		/		/		NAVY ACQUISITION AND MAINTENANCE		
PRE-OPERATIONAL			OPEVAL			MSD		NSD	
						TRANSITIONAL		FULL ORGANIC	

Figure 5. F/A-18 Phased Support [Ref. 6:p. 40]

in St. Louis [Ref. 6:p. 71]. The North Island location was chosen because the facility had already been selected as the eventual Cognizant Field Activity, responsible for depot level maintenance and periodic overhaul of the aircraft.

In order to provide additional visibility for the management of the logistic support elements, the functional systems of the aircraft (e.g., landing gear system, fuel system, etc.) were assembled into nine functional groups. Figure 6 displays the functional groups and their respective systems. The systems are grouped based on their similarity in engineering requirements and the necessary educational and experience backgrounds of their designers [Ref. 6:p. 41]. The primary function of the team's organization is to assist the APML in managing the ILS elements within each functional group. While the Logistics Element Managers in NAVAIR retained cognizance of the elements and could make cost, schedule, and performance tradeoffs within their specific elements, the support system development within each functional group was monitored by the NARF Logistics Support Team. Following identification of a difficulty within a functional group by the NARF team, the APML could use higher order tradeoffs across elements as a possible solution. In this way, not only was the support system development managed by each ILS element, but also with a focus on the hardware functional systems of the aircraft itself.

Group A Hydraulic Systems		Group B Airframe		Group C Pneumatic	
System No.	Title	System No.	Title	System No.	Title
02	Hydraulic Power System	18	Fuselage	03	Bleed Air System
15	Landing Gear System (Including Catapult)	19	Wing	07	Air Conditioning System
18	Arresting Gear System	20	Stabilizers (Vertical)		
		22	Doors/Covers		
Group D Life Support		Group E Power Plant		Group F Aircraft Support	
System No.	Title	System No.	Title	System No.	Title
00	Oxygen System	05	Auxiliary Power Unit System	01	Electrical Power System
13	Emergency Equipment	12	Fuel System	08	Ice and Rain Protection System
14	Escape System (Including Canopy)	26	Power Plant	10	Fire Protection System
		27	Power Plant Installation	11	Lighting System
		28	Accessory Drive System	47	General Instruments
				51	Warning and Caution Advisory Systems
Group G Flight Aids		Group H Communication/Navigation		Group I Weapons Systems	
System No.	Title	System No.	Title	System No.	Title
17	Flight Control System	33	VHIF Communications	43	Weapon Control System
40	Flight Reference System	34	UHIF Communications	44	Weapon Delivery System
50	Flight Control Set	36	IFF System	45	Electronic Countermeasures
		38	Integrated Comm Nav IFF Package		
		40	Radio Navigation		
		41	Radar Navigation		
		42	Bomb Navigation		

Figure 6. F/A-18 Logistic Support Functional System Groupings
[Ref. 17:p. 9-5]

The responsibilities of the NARF Logistic Support Team were summarized as threefold: [Ref. 20:p. 3-19]

1. To verify that the maintenance resources, identified by the contractor, meet the support concepts.
2. To monitor the acquisition of assets and make support tradeoff recommendations between ILS elements and also functional systems.
3. To assess supportability and monitor changes.

F. APML ROLE IN SUPPORT MANAGEMENT

Traditionally, the Assistant Program Manager for Logistics has had the responsibility for coordinating the overall support system for an aircraft program. His primary purpose is to ensure an ILS system that will meet established program objectives. The ability of the APML to accomplish these tasks was significantly strengthened on the F/A-18 program. For the first time, the APML was placed in the funding flow from the PMA to the Logistics Element Managers.

This management technique is consistent with the bias to action evident throughout the F/A-18 support system development. The support system management is focused on recognizing the inherent characteristics of the system and planning early to accommodate them. The phased support concept recognizes that all support equipment will not be available on a specific date and requires management by functional group. Tradeoffs among functional groups or elements of support may be necessary to accommodate the situation.

Placement of the APML in the funds flow process enables him to make adjustments as necessary from the perspective of the support system as a whole. [Ref. 6]

G. COMPETITIVE PROCUREMENT OF SUPPORT EQUIPMENT

The consistent theme of high readiness rates through supportability and the complexity of the onboard avionics had influenced the F/A-18 program toward maximum utilization of Automatic Test Equipment (ATE).¹ In concert with the NAVAIR policy of decreased proliferation of PSE, Automatic Test Equipment that was currently in the Navy inventory was to be used to the greatest extent possible. An example of ATE in the current inventory used extensively is the Versatile Avionics Shop Test (VAST). VAST is used at the intermediate maintenance level to perform diagnostic tests on the avionics components of various types of operational aircraft. In order to test avionics components of various configurations on test equipment of a standard configuration, an intermediate device is required. This link is called the Test Program Set (TPS).

A TPS consists of four items--two of a software nature and two of a hardware nature--though occasional exceptions do exist. The software components consist of the Test Program Instruction, a set of directions to the operator on

¹Automatic Test Equipment is equipment that carries out a predetermined program of testing for possible malfunction without reliance upon human intervention.

how to perform a diagnostic test with this particular TPS and component, and the Test Program Medium, a magnetic tape which contains the electronic instructions to the test equipment required to perform fault isolation on a particular piece of avionics equipment. The hardware components consist of the interface device, an assemblage of electronic parts which serves as a translator between the component under test and the test equipment and the necessary cables to connect the interface device to the test equipment.

The F/A-18 program had experienced significant cost growth in the development of many Test Program Sets for its complex avionics equipment [Ref. 21:p. 10]. In several cases, the cost of the manual software development was greater than the cost of the ATE itself [Ref. 16:p. 3-13]. In an attempt to reduce the escalating cost of these items, the Support Equipment Division (AIR-552) submitted a proposal to competitively procure approximately 200 Test Program Sets required for the program. It was estimated that the total cost of the Test Program Sets for the aircraft could be reduced by \$70 million with no adverse impact on performance capability or schedule [Ref. 21:p. 27]. In 1982 the Program Management Office made the decision to authorize competitive procurement of these Test Program Sets [Ref. 22]. The competition was to be managed by the Support Equipment Division.

H. SUMMARY

This chapter has reviewed the innovations in support system development that were instituted with the F/A-18 program. The increasing complexity of modern weapon systems and their attendant low readiness rates were the primary impetus behind the philosophy adopted for the F/A-18 program. An emphasis on early planning for support was employed to attempt to influence the design of the aircraft toward supportability. A phased support program was developed to provide an orderly transition from contractor support to full organic (Navy) support. Establishment of a Logistics Support Team at NARF North Island provided the APML with technical support and the ability to manage the support system from a functional hardware perspective. The role of the APML was significantly strengthened by his placement in the funding flow from the PMA to the Logistics Element Managers. Finally, the competitive procurement of peculiar support equipment to limit program cost growth was utilized for the first time.

IV. EVALUATION OF SUPPORTABILITY INNOVATIONS

A. INTRODUCTION

The effectiveness of the innovations enumerated in Chapter III was determined by conducting interviews of key personnel currently involved with the F/A-18 program. The perspectives of the three major participants in the program/functional matrix with respect to support equipment, the APML, SPM-SE and PMA were assumed to be the most knowledgeable evaluators. Because the current F/A-18 PMA has been with the program only a short while, the Deputy PMA, who has a long-term history with the program in various capacities, was consulted. Numerous additional interviews were conducted both within the Program Management Office and through the section level of the functional divisions. This data was compared/contrasted with the material from the Beran and Decker study [Ref. 6] to reach the conclusions and recommendations listed in Chapter V.

B. ADVANCE PLANNING FOR SUPPORT

The proven availability of the F/A-18 weapon system attests to the success of the support planning effort. The aircraft has already established a reputation for low maintenance requirements and ease of maintenance. One example is the fact that an engine can be changed in the "shadow" of the aircraft (i.e., minimal support equipment) in less than

30 minutes. This is an improvement by a factor of two to four times over existing fighter and attack type aircraft [Ref. 22]. After two deployments of the aircraft, reliability data submitted by fleet units has prompted a recommendation from NAVAIR that a major maintenance inspection, conducted every 100 flight hours, be extended to an interval of 200 flight hours. This adjustment is expected to result in a reduction of approximately 50 percent in the man-hours expended on preventative maintenance for the aircraft and an attendant decrease in support equipment requirements. [Ref. 22]

A particular bright spot, of a technological nature, resulted from the program's early and continuing emphasis on support. The inclusion of Built-In Test/Built-In Test Equipment (BIT/BITE) capability in the aircraft's avionics equipment has served to reduce fault isolation times and increase fault isolation accuracy. The success of this approach has brought about a new way of thinking in AIR-552. Future support planning efforts of the Support Equipment Division will be aimed at meeting with the manufacturer of the component as early as possible in the design review process in order to influence a design toward improved BIT/BITE capability as well as supportability. The ultimate goal will be a component that will fault isolate itself [Ref. 23]. This is consistent with the established NAVAIR goals (in descending order of preference) of: [Ref. 23]

1. No support equipment.
2. The use of common support equipment.
3. Modification of existing common support equipment or procurement of new peculiar support equipment.

In those items which cannot be made to completely self-test, emphasis is being placed on utilization of the BIT/BITE by the ATE as an integral part of the test procedure itself. This will serve to reduce the complexity of the ATE and also to reduce fault isolation times.

Another AIR-552 initiative is to encourage performance of the Logistic Support Analysis (LSA), from which support equipment requirements are generated, at an earlier point in the acquisition process. Currently, the LSA is performed in the Full Scale Development Phase of the acquisition process when many (up to 90 percent) of the component design variables are firmly established [Ref. 23]. At this point, any design changes to influence supportability/testability become more technically difficult and consequently, more costly. AIR-552 advocates performing the initial LSA in the Demonstration and Validation Phase. This will maximize the opportunity to influence design toward optimization of both support and performance. [Ref. 23]

An additional concern surrounding the LSA process is the prompt delivery of the LSA documents for NAVAIR review. Although the LSA, which is performed by the contractor and verified by NAVAIR, may be conducted at an earlier point in the program, this does not guarantee the LSA products will

be delivered to NAVAIR in a timely fashion. Since the LSA drives the determination of support equipment requirements, any delay in the LSA documents will result in a corresponding delay in SE development and delivery. It is imperative that the Navy set and enforce a firm delivery schedule for the LSA products [Ref. 23]. The use of contractual incentives or penalties may be of assistance in this area.

In order to further expedite the support equipment identification process, an initiative is underway to organize AIR-552 and the support equipment technical specialists at NAEC along functional lines such as propulsion and communication/navigation equipment. This organization will facilitate attendance of all SE cognizant personnel at early design reviews.

Also in concert with the theme of early support planning is the planned utilization of a Support Equipment Candidates List [Ref. 23]. This document would be prepared in the very early stages of the support equipment requirements determination process. It will reflect obvious, known SE requirements as agreed upon by both Navy and contractor representatives. Because preparation of the Support Equipment Candidates List would be significantly less complicated than the formal determination process, it can be prepared at an earlier point in the process. This action will provide an even earlier start on the development and procurement of known support equipment requirements.

The RILSD was disestablished in the 1984 time frame [Ref. 22]. Their initial work on the Logistic Support Analysis and Maintenance Plan was transferred to NARF North Island. The NAEC representative for support equipment, however, is still active at the contractor's facility in St. Louis. All those interviewed were in agreement as to the value of the SE representative, especially in the early stages of the program [Refs. 22, 23]. In addition to providing technical assistance, the representative is a valuable aid in expediting government administrative requirements pertaining to support equipment. The NAEC representative is still very much a part of the logistics process and is providing assistance on current problems. Representative tasks include a program to provide Test Program Set vendors component update information. The consensus among current program personnel involved in the support effort was that all on-site liaison with the contractor was a valuable asset [Refs. 22, 23]. NAEC representation at all support equipment contractors has become standard practice in AIR-552 [Ref. 23].

Contract incentives for supportability were termed a huge success by the current Deputy PMA [Ref. 13]. The incentive awards were based on reliability and maintainability goals. As reliability increases (higher mean time between failure) and maintainability improves (lower mean time to repair when a failure does occur), the requirements

for all support elements are decreased. The prime contractor's efforts in improving these areas were so successful that he was able to earn all of the available reliability and maintainability incentive awards [Ref. 13]. This acquisition technique was crucial in the design and delivery of the F/A-18, currently the most reliable and maintainable aircraft of its type in the fleet [Ref. 13]. As such, contract incentives for reliability and maintainability (and therefore supportability) have been adopted by several other NAVAIR aircraft programs such as the T-45 and the V-22 [Ref. 13].

Prioritized development of maintenance capabilities was another technique endorsed by all interviewees. In addition to the early stages of the development, this technique has been utilized on a continuing basis throughout the program as the maintenance levels are developed. Currently, the priorities of the depot level maintenance tasks are being reevaluated based on failure rates observed in the fleet. On some components, the actual failure data is indicating 20,000 to 30,000 hours mean time between failure, much higher than was originally projected. This has led to changes in priority on, and in some cases elimination of, maintenance and testing on these items. [Ref. 22]

This practice has a direct and significant effect on support equipment. Preliminary mean time between failure estimates are a major determinant in developing initial SE

nts. As a consequence, the Navy may be buying SE above case, Test Program Sets) which it does not conversely, if the actual MTBF rates are lower than estimated, SE requirements would be greater than needed. The current APML stressed the need to maintain a support program, continuously refining requirements through feedback from the fleet. Corrective actions adjusting support equipment procurement schedules as a task to a higher or lower maintenance level as [Ref. 22]

Addressed earlier, the F/A-18 program embodied a phased plan to incrementally transition support from the prime contractor to the Navy. The F/A-18 support plan was roundly lauded by all personnel involved. Phased support was credited with "saving" the when difficulties were experienced with the delivery of Program Sets to support ATE (to be discussed in a later section) [Ref. 13]. Comments from an earlier F/A-18 Test Program Director for Tactical Air Programs (viewed phased support as a necessity for any order to bring the weapon system on-line without delay [Ref. 24]. The F/A-18 phased support plan was especially valuable in that it permitted the shift of organic support elements to be based on a high level of design maturity, rather than a changing level of design maturity [Ref. 24]. A widely acknowledged strength of the

F/A-18 phased support plan was the fact that it had been planned from the beginning of the aircraft acquisition [Ref. 25]. Overall it was felt that the aircraft could not have been introduced and maintained the high readiness rates it has without phased support.

In theory it seems that a conflict may exist for a contractor who, like McDonnell Douglas in the F/A-18 program, is providing both the interim support and developing equipment and procedures for organic support. One could speculate that the contractor may be inclined to delay development of the organic support in the event of technical or contractual difficulties with support equipment. Additional motivations could be a desire to retain the profit generated by the interim support contract as long as possible or an unanticipated need to focus resources on the development of the weapon system, thereby reducing the effort on support development.

This concept was suggested to F/A-18 PMO personnel, both past and present, and was unanimously judged to be a highly unlikely occurrence. The NAVAIR personnel felt that the major contractors would rather concentrate on selling their primary products [Ref. 24]. It was felt the contractor accepted the requirement to perform interim support as a consequence of selling their product [Refs. 13, 24]. Another view expressed was that the contractor would have more to lose than gain by delaying development of organic

support capabilities. The negative risk here being the contractor gaining a reputation within the military community as producing a complex system that is difficult to support with organic assets. [Refs. 22, 24]

D. NARF NORTH ISLAND LOGISTIC SUPPORT TEAM

As stated earlier, the Logistic Support Team was originally intended to be established at the contractor's facility in St. Louis. The North Island site was the next logical choice as it had been designated as the eventual Cognizant Field Activity for the aircraft.

In the earlier study, the following potential weaknesses were advanced as to the effectiveness of the Logistic Support Team at North Island: [Ref. 6:p. 71]

1. Ideally the Logistic Support Team should be physically located at the contractor's facility.
2. The choice of team members is limited.
3. NARF North Island management goals for the Logistic Support Team may not be the same as the program goals for this team.

In reference to location, it was projected the team's required interaction with other groups in the program support organization would be difficult to maintain [Ref. 6:p. 72]. In light of the fact that none of the other groups were on the west coast (APML, LEMs-NAVAIR, NAEC-east coast, RILSD and contractor personnel in midwest) this view is easily understandable. This projection has, in fact, proven true. The extensive travel required and the time difference

between coasts has significantly reduced the effectiveness with which the Logistic Support Team can be managed by the APML [Ref. 22]. Conversely, the above conditions have lessened the frequency with which the Logistic Support Team perspective is sought in making routine support system decisions. [Ref. 22]

Addressing the area of personnel, the earlier study suggested that the limited pool of personnel available at the NARF, from which members would be selected, could limit the effectiveness of the team. This was in contrast to the make-up of the RILSD, both in this program and those in the past, whose members were selected from various backgrounds and organizations. A noted strength of the RILSD was the broad and balanced spectrum of knowledge and experience available to accomplish day to day coordination [Ref. 6:p. 72]. No current deficiencies were identified in either the variety of skills or the competence levels of the personnel on the NARF team, however, the effectiveness of the team was found to be highly dependent on the incumbent leadership. This situation had varied considerably in the past. [Ref. 22]

The projection of conflicting goals between program and NARF management centered primarily on the dichotomy in time horizons between the two organizations. The PMO is obviously concerned with introducing a weapon system to the fleet that meets performance and supportability goals. It

was postulated that the NARF Logistic Support Team would tend toward a longer term perspective and base their decisions from an overhaul and rework viewpoint [Ref. 6:p. 73]. Primary concerns would be the maintenance and increase of production levels which in this case would involve depot level maintenance and rework of the aircraft at prescribed intervals (usually a period of three to six years). Research conducted for this thesis indicates that this deficiency may have been realized. One incident that was related will serve to illustrate the point.

A technique known as age expiration was under consideration for the F/A-18 program. The age expiration technique bases the decision to rework aircraft at the depot level on the condition of a sample of aircraft taken from the aircraft population. This is contrasted to the Standard Depot Level Maintenance (SDLM) program, which reworks each model aircraft on a standard service period interval. Both the sample inspection and aircraft rework are performed by NARF personnel. A difference of opinion developed over the appropriate sample size for the F/A-18 between the APML and NARF North Island [Ref. 22]. The sample size varies directly with the desired confidence level of the test (i.e., a 95 percent confidence level would require a larger sample than a 90 percent confidence level). The desire of the APML, in an effort to conserve resources and maintain the validity of the technique, was to use a sample size at

the lower end of the acceptable range. The NARF team strongly advocated a higher confidence level and therefore a larger sample size, requiring a greater expenditure of time and funds. Since NARF personnel conduct the sample inspections, and subsequent rework if necessary, the size of the aircraft sample is directly related to the workload at the NARF. One must therefore question the extent to which the recommendation of the Logistic Support Team has been influenced by NARF management goals. [Ref. 22]

In summary, the Logistic Support Team at NARF North Island was found to have minimal impact on logistic support decisions by the PMO. The location of the team made communication and coordination difficult and the effectiveness of the team was found to vary significantly with the leadership. Additionally, the objectivity of the team was called into question. These conclusions were in general agreement with the projections of the earlier study.

E. APML ROLE IN SUPPORT MANAGEMENT

One of the most significant changes in the F/A-18 program from previous aircraft acquisition programs was the enhancement of the APML role in managing the support system. This was accomplished by placing the APML in the funding flow from the PMA to the Logistics Element Managers. The research conducted for this thesis found the method by which the APML role was enhanced to be significantly different than that which was reported by Beran and Decker [Ref. 6].

In the earlier study, there are numerous references to funding control by the APML. The control of funds by the APML is explicitly stated when the "Golden Rule" is referenced [Ref. 6:p. 67]. The "Golden Rule" asserts "He who has the gold, makes the rules." [Ref. 6:p. 67] This leads the reader to the conclusion that the APML controls and disburses program funds to the various logistics elements. Program fund management, as described above, is in direct conflict with the current charter of the Program Manager which states, "The Program manager shall control all funds approved for the program" [Ref. 5:p. 6]. This version of the PMA charter was published after the earlier study, but no individual interviewed could recall APML control of funds throughout the history of the program.

Although the F/A-18 APML was not given actual control of support funds for the program, he does wield significant influence in how the funds are budgeted and distributed. The APML is in the funding flow in an advisory capacity to the PMA. In this alignment, the APML and his staff consolidate, approve as consistent with the overall support plan, and submit all support element budget requests to the PMO. Following funding approval, the APML closely monitors obligations to ensure support spending is proceeding as planned. The APML is able to alter the support mix and make tradeoffs among elements through his inputs to the PMA. The success of this technique is highly dependent on the PMA.

It is only through the PMA's insistence and reliance on APML input that the APML is able to fully integrate the various support elements through funding.

This management practice was endorsed by all those interviewed. The current F/A-18 Deputy PMA and a former PMA both placed high value on the APML role in this process. The excellent readiness posture of the F/A-18 in the fleet was in part credited to this management structure [Refs. 13, 24]. Neither considered it an attenuation of PMA authority, as suggested by the earlier study [Ref. 6]. This is a reasonable conclusion in that the PMA retains ultimate control of funds. In fact, both cited the practice as an area better handled by the APML and one that had improved overall program management [Refs. 13, 24]. Specifically, the monitoring function had proven valuable in the early identification of problem areas and thus gave ample opportunity to explore alternative methods [Ref. 24]. The current APML enthusiastically endorsed the concept. Tradeoffs among support elements and across the board reductions in funding had been accomplished via this method on many occasions [Ref. 22]. Short notice budget decisions were cited as being of higher quality. This was attributed to the APML's better understanding of relative priorities within the ILS program as compared to a financial representative from the Project Management Office. [Ref. 22]

The logic of this approach seems so sound that it is surprising that it was not used on programs prior to the F/A-18. One possible explanation is again indicative of the commitment to support on the F/A-18 program. On this program, while the APML is charged with screening and monitoring support element expenditures, he is also adequately staffed to perform this function. Currently, the financial management task in the F/A-18 APML staff involves a full time Supply Corps officer and several contractors performing record keeping tasks to manage a budget in excess of \$500 million per year [Ref. 22]. In the past (and on several other current programs) the APML was not sufficiently staffed to perform these functions. [Ref. 22]

Another area investigated in the Beran and Decker work concerned the organizational effects that may have resulted from the enhancement of the APML role in support management. In reference to support equipment, it was theorized that the change in the APML role would be perceived as a diminution of the role of the System Program Manager for Support Equipment [Ref. 6:p. 66]. Additionally, because of the fact the APML is organized under AIR-04 and the SPM-SE is organized under AIR-05, it was thought any conflict resulting from the change would be difficult to resolve across organizational lines [Ref. 6:p. 70]. It was not possible to ascertain if these problems were a factor in the very early years of the program. None of those interviewed for this thesis could

recall any difficulties with the arrangement dating back to the 1979-1980 time frame [Refs. 13, 23]. The principal member of the organization affected, the current SPM-SE, strongly endorsed the APML role in funds management as currently configured [Ref. 23]. This is consistent with the fact that the APML does not control any funds, but rather screens requests and makes recommendations. If a conflict does arise relative to support equipment funding, the SPM-SE, chartered with responsibility for all NAVAIR SE programs, can take his case directly to the PMA. Also, the motivation of the APML to unfairly recommend restriction or reduction of support equipment funding must be questioned. The APML is responsible for ensuring an adequate support system for the aircraft by balancing the support elements. If he arbitrarily recommends cuts in SE, he cuts support [Ref. 23]. A movement toward stronger enhancement of the APML role in future programs was predicted, to include eventual APML control and disbursement of support funds. [Ref. 23]

F. COMPETITIVE PROCUREMENT OF PECULIAR SUPPORT EQUIPMENT

Competition has been successfully employed in the procurement of common support equipment for many years. Typically the required common support equipment is a proven product with little or no development involved [Ref. 26:p. 46]. Peculiar support equipment, on the other hand, is unique to a particular aircraft or system and usually

requires extensive development. As a consequence of its unique nature, of the over 3000 peculiar support equipment design and development programs in progress, virtually all are with the weapon system prime contractor. [Ref. 26:p. 49]

As mentioned earlier, the F/A-18 program had experienced significant cost growth in a particular area of PSE development--that of Test Program Sets (TPS) to interface the aircraft's avionics components with existing and new Automatic Test Equipment (ATE). In response, a decision was made to competitively procure a portion of the TPS requirements. This was the first time in any NAVAIR aircraft program that PSE was to be competed. [Ref. 23]

The results of the TPS competition have been less than successful [Refs. 13, 22, 23]. The dissatisfaction within the program centers around the consistent late delivery of the Test Program Sets. The decision to compete this equipment was made in 1982. As of late 1986, no TPS had been delivered on schedule and the majority of those that had been delivered were in a pre-production configuration [Ref. 22]. Those in the pre-production configuration have little of their ILS system in place and normally require a technical representative of the manufacturer to operate them. [Ref. 22]

A common theme was found in the research conducted on the TPS procurement. The shortcomings in this area centered around three topics:

1. Technical data, in the form of Test Requirements Documents (TRD).
2. Samples of the components which the TPS is designed to interface with, known as the Unit Under Test (UUT).
3. The ability to upgrade the individual TPS to match the upgrade of its respective avionics component.

Test Requirements Documents contain the full technical data package applicable to a particular component. Typically the documents contain circuits, schematics, and all required test parameters. In the case of TPS development, a data package is required for each component a TPS is designed to test. This presented a significant management problem for AIR-552. While collecting and distributing the data packages for 200 Test Program Sets does not seem overwhelming, this task was complicated by the fact that three different manufacturers were contracted to develop and produce the sets, resulting in three different data package requirements. An additional complicating factor that was not anticipated was erroneous data. Any TRD that was in error and provided to a developer would result in a Test Program Set that would not function properly. The task of ensuring all data was screened for accuracy imposed a substantial workload on AIR-552 [Ref. 23]. On previous programs, where PSE was procured sole source from the prime contractor, these tasks were performed by the prime.

Samples of the components to be tested, Units Under Test, are essential to TPS development. The primary problem in this area concerned the fact that the decision to compete the TPS development was made at a later point in the program than when spares requirements were identified [Ref. 23]. Consequently, dedicated components for TPS development were not procured. The program has had to draw from any opportune source in order to overcome this deficiency. Currently, two production aircraft are in long term storage at NARF Jacksonville, Florida, with the required components removed. The sole reason for these aircraft to be in this status, and expected to remain that way for approximately one year, is to provide Units Under Test for TPS development [Ref. 22]. On previous programs, with the prime managing TPS development, this problem was easily solved by pulling the required components from the production line. [Ref. 23]

A contributing factor to both schedule delay and increased cost was the failure to include in the TPS development contract a provision to update the Test Program Sets as the avionics components in the aircraft were improved [Ref. 22]. Several examples were cited where the components have been upgraded four or five times before the TPS for the original version has been delivered [Ref. 22]. In most cases the TPS for the original component will not correctly test the updated components. Corrective actions

range from a simple publications change to document a change in testing procedure to a complete rewrite of the software portion of the TRS. Some TPS modifications involving software rewrites have amounted to 60 percent to 90 percent of the cost of the original TPS. [Ref. 27]

Another related problem area in TPS development is configuration control of Automatic Test Equipment [Ref. 23]. Improvements are frequently proposed and incorporated in the test equipment itself. It can be easily seen that with the TPS required to interact with both the component and the ATE, a complex situation can rapidly develop when both configurations are changing. Because NAVAIR provided the ATE to the TPS developers in the competitive arrangement, it was responsible for ensuring updates were processed and incorporated promptly. [Ref. 23]. This task also had previously been accomplished by the prime contractor.

In summary, the problems associated with the TPS competition involve NAVAIR assumption of tasks formerly performed by the prime contractor. The competition did yield some benefits. The competitive price of the package was approximately half that of procurement solely from the prime [Ref. 23]. This has established a new market price for future TPS development. However, what AIR-552 saved in development costs was bought with an assumption of management tasks and responsibilities. Program delays resulted from a failure to anticipate the complexity of directing three competitors and

a lack of advance planning on other related issues. One ripple effect of this situation has been a necessary extension of the phased support plan [Ref. 13]. it is interesting to note that the Beran and Decker study projected that the management tasks associated with competitive procurement of PSE would be formidable and probably result in schedule delays [Ref. 6:p. 75]. As a result of the problems encountered in this area, the F/A-18 program has elected not to participate in further PSE competition [Ref. 22]. On the remaining lots of Test Program Sets to be developed, the PMA has directed AIR-552 to contract with McDonnell Douglas directly. [Ref. 13]

G. OTHER ORGANIZATIONAL ISSUES

The earlier study pointed out a potential weakness in the matrix structure. While the functional groups are normally headed by an admiral, the PMA is usually a Navy captain or a Marine Corps colonel. Because the functional divisions remain organizationally in line with the functional group, it was contended the functional group director could exert considerable influence over an individual program's operations. [Ref. 6:p. 49]

No evidence was found to indicate this behavior had ever been a consideration in the F/A-18 program. The current PMA was well satisfied with the program/functional matrix concept [Ref. 13]. No significant conflicts had been experienced between the PMO and the functional

groups/divisions [Ref. 13]. In addition, it was pointed out the PMA charter stated that in the event of a conflict the functional divisions would support the PMA decision until the situation was resolved by higher authority [Ref. 13]. It seems clear that a teamwork approach pervades the matrix organization in the support area and that the F/A-18 program is recognized as a NAVAIR program, not strictly an endeavor of the Program Management Office.

A significant change was also instituted concerning the Integrated Logistic Support Management Team (ILSMT) for the aircraft itself, mentioned in Chapter II. The F/A-18 Integrated Logistic Support Plan states, "The primary management vehicle of the ILS program is the ILSMT, which serves to monitor and control the execution of overall program requirements" [Ref. 17:p. 2-5]. The earlier study proposed that the "monitor" function would be assumed by the Logistic Support Team at NARF North Island and the "control" function by the APML [Ref. 6:p. 66]. The control function has been effectively assumed by the APML. Although the Logistic Support Team has not emerged to be as strong a participant as originally planned, their work has enabled the ILSMT role to be reduced. Currently, the ILSMT meetings have been consolidated with safety and engineering meetings to form a single SEAL (Safety, Engineering and Logistics) meeting [Ref. 22]. Many of the same people were attending all three meetings and, in the APML's opinion, the dedicated

ILSMT meetings of the past had been unproductive, concentrating primarily on status briefs of current ILS issues. Consolidation was viewed as a means to reduce travel requirements, and to increase interaction between the three groups and with fleet personnel. The SEAL meeting format has been in effect for approximately one year and has already yielded benefits in the form of an increased focus on action items generated from fleet inputs, decreased time commitments on the part of the members, and enhanced interaction between disciplines. [Refs. 13, 22]

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The success of the F/A-18 approach to support system planning and management cannot be disputed. The aircraft itself has brought about a new mode of operation for fleet maintenance managers and technicians, where reliable and easy to maintain systems are the rule rather than the exception. The management innovations implemented with this program have set a standard for other programs to follow.

Early consideration of support requirements and the opportunity to influence component design toward supportability are crucial aspects of a successful program. Phased support, coupled with prioritized development of maintenance capabilities, permits synchronization of the design maturity of the support system with that of the aircraft.

In order to provide accountability and a single point of responsibility, it is desirable that the PMA retain control of all program funds. However, to truly manage the development of the support system, the APML must have the ability to influence PMO decisions regarding the individual support elements. The APML can accomplish this through participation in the funding flow as established in the F/A-18 program. To effectively perform this tasking, the APML must be adequately staffed.

While the competitive procurement of peculiar support equipment can substantially lower equipment costs (50 percent in the case of the F/A-18 Test Program Sets), it entails the assumption of a substantial management workload which must be adequately planned and provided for.

The program/functional matrix is well conceived and structured. There is no evidence in the F/A-18 program that conflict has occurred between the functional divisions and the PMO. If conflict does arise, the procedures to handle it are well documented. The interplay of program and functional responsibilities adds strength to the organization.

B. RECOMMENDATIONS

1. Recommendation 1

The emphasis on early support planning and design for supportability should be continued. All methods by which support equipment requirements can be identified at an earlier point in the acquisition cycle should be pursued. This is to include initiation of the Logistic Support Analysis during the Concept Exploration stage and the use of the Support Equipment Candidates List. The inclusion of these methods in a program proposal should be adopted as one of the criteria to be evaluated during the source selection process. The design for support effort should strive for the utilization of BIT/BITE capability wherever feasible. The prompt establishment of the RILSD, to include a

dedicated support equipment representative, is a proven practice and should be continued.

2. Recommendation 2

Contract incentives for support are integral to adequate support system development and should be used on all aircraft weapon systems acquisition contracts. To effectively administer the incentive program, the awards should be based on quantitative goals such as reliability and maintainability. Also, the awards should be determined on data that are collected in the operational environment with maintenance performed by Navy personnel.

3. Recommendation 3

Phased support for the introduction of new weapon systems should be adopted as standard practice in NAVAIR. This concept must be planned from the initiation of the program and include provisions for the transition of both maintenance and supply support. The rate at which the various maintenance levels transition should be based on the rate of design maturity of the aircraft. The possibility that a prime contractor would intentionally delay the development of organic maintenance capabilities for his own gain is considered remote.

4. Recommendation 4

The establishment of a team to assist in logistics management at a location other than the manufacturer's facility should not be considered. Placement of the support

team at another location, especially when a substantial geographic separation exists, places them outside the logistics decision making process. Organization of the team to enable management by aircraft functional system can yield benefits and should be pursued if the team can be established at the contractor's facility.

5. Recommendation 5

The APML should be directly involved in funding decisions for the support elements in order to provide a balanced approach to ILS. To accomplish this, the APML must be adequately staffed. In order to ensure a single point of control and accountability, the F/A-18 program method is preferred over a procedural change which would give the APML actual control of the funds.

6. Recommendation 6

The efforts to competitively procure peculiar support equipment should continue. The planning and management problems encountered on the F/A-18 program can be applied to improve the chances for success on future contracts. The opportunities to reduce program cost are too great to ignore.

7. Recommendation 7

The program functional/matrix organization in NAVAIR should be retained. The structure is well established and able to accomplish program goals efficiently. The potential

for conflict between program management and functional groups has been effectively minimized.

APPENDIX A

INTEGRATED LOGISTIC SUPPORT

Integrated Logistic Support is defined as a "disciplined, unified, and iterative approach to the management and technical activities necessary to: [Ref. 28:p. 2-2]

- a. Integrate support considerations into system and equipment design.
- b. Develop support requirements that are related consistently to readiness, objectives to design, and to each other.
- c. Acquire the required support.
- d. Provide the required support during the operational phase at minimum cost.

In response to an acknowledged requirement for a more thorough approach to logistics planning, the Navy issued Weapon Requirement-30 (WR-30) entitled "Integrated Maintenance Management for Aeronautical Weapons, Weapon Systems and Related Equipment," in 1963 [Ref. 6:p. 84]. The ILS concept was further established throughout DOD with the issuance of DOD Directive 4100.35, "Development of Integrated Logistic Support for Systems and Equipment" in the following year. NAVAIR ILS program requirements for ILS were promulgated in Aeronautical Requirement-30 (AR-30), published in 1969 and further refined in AR-30A, published in 1971. The most recent Department of Defense ILS guidance is DOD Directive 5000.39 of 1983, "Acquisition and

t of Integrated Logistic Support for Systems and
." This document is significant in that it states:

selection evaluation criteria for appropriate
tive programs shall include a separate evaluation
(separate from schedule, cost, and performance) for
ss and support, weighted to ensure a positive
on contractor selection and contract award.

ed the first DOD publication where logistic support
recognized on an equal basis with cost, schedule,
ormance with reference to source selection. DOD
5000.39 was implemented in its entirety throughout
by Secretary of the Navy Instruction (SECNAVINST)
in 1986. In addition to the precepts published in
Directive, SECNAVINST 5000.39A further emphasized
tance of logistic support in program management:

agers and other professional logistics personnel
e afforded equality of grade and rank with other
ional personnel engaged in other equally important
f acquisition such as design engineering, produc-
ontracts management, financial management, etc.

irective 4100.35 was the first government publica-
identify the primary elements of logistic support
[1. 84]. Because ILS is an evolving discipline,
been some disagreement in the literature on the
inition of the ILS elements. The ILS Elements as
DOD Directive 5000.39 and SECNAVINST 5000.39A are
s:

Maintenance Planning. The process conducted to evolve
establish maintenance concepts and requirements
the lifetime of a material system.

Power and Personnel. The identification and acqui-
on of military and civilian personnel with the

skills and grades required to operate and support a material system over its lifetime at peacetime and wartime rates.

3. Supply Support. All management actions, procedures, and techniques used to determine requirements to acquire, catalog, receive, store, transfer, issue and dispose of secondary items. This includes provisioning for initial support as well as replenishment supply support.
4. Support Equipment. All equipment (mobile or fixed) required to support the operation and maintenance of a material system. This includes associated multiuse end items, ground-handling and maintenance equipment, tools, metrology and calibration equipment, test equipment, and automatic test equipment. It includes the acquisition of logistic support for the support and test equipment itself.
5. Technical Data. Recorded information regardless of form or character (such as manuals and drawings) of a scientific or technical nature. Computer programs and related software are not technical data; documentation of computer programs and related software are. Also excluded are financial data or other information related to contract administration.
6. Training and Training Support. The processes, procedures, techniques, training devices and equipment used to train civilian and active duty and reserve military personnel to operate and support a material system. This includes individual and crew training; new equipment training; initial, formal, and on-the-job training; and logistic support planning for training equipment and training device acquisitions and installations.
7. Computer Resources Support. The facilities, hardware, software, documentation, manpower and personnel needed to operate and support embedded computer systems.
8. Facilities. The permanent or semipermanent real property assets required to support the material system, including conducting studies to define types of facilities or facility improvements, locations, space needs, environmental requirements, and equipment.
9. Packaging, Handling, Storage, and Transportation. The resources, processes, procedures, design considerations, and methods to ensure that all system, equipment, and support items are preserved, packaged,

handled, and transported properly, including environmental considerations, equipment preservation requirements for short- and long-term storage, and transportability.

10. Design Interface. The relationship of logistics-related design parameters, such as R&M, to readiness and support resource requirements. These logistics-related design parameters are expressed in operational terms rather than as inherent values and specifically relate to system readiness objectives and support costs of the material system.

The ILS process can be divided into several different sections. This appendix will discuss four primary actions undertaken during the ILS process, listed as follows:

1. Definition of the system maintenance concept.
2. The Integrated Logistic Support Plan.
3. Logistic Support Analysis.
4. The maintenance plan for the system.

A. SYSTEM MAINTENANCE CONCEPT

"System support must be considered on an integrated basis from the beginning if the ultimate product is to be cost-effective. This is initially accomplished through the definition of a system maintenance concept, which evolves from the definition of system operational requirements. The maintenance concept basically describes in general terms the overall system support environment in which the system is to exist, and constitutes the baseline for the determination of specific logistic support requirements through the Logistic Support Analysis. More specifically, the maintenance concept serves the following purposes:

1. It provides the basis for the establishment of supportability requirements in system/equipment design. It also provides design criteria for major elements of logistic support (e.g., test and support equipment, spares, facilities, etc.). For instance, if the repair policy dictates that no external test and support equipment is allowed at the operational site, then the prime equipment design must incorporate some provision for built-in self-test.
2. It provides for the establishment of requirements for total logistic support. The maintenance concept, supplemented by the logistic support analysis, leads to the identification of maintenance tasks, task frequencies and times, personnel quantities and skill levels, test and support equipment, spare/repair parts, facilities, and other resources.
3. It provides a basis for detailing the maintenance plan and impacts upon the supply concept, training concept, supplier/customer services, phased logistic support, transportation and handling criteria, and production data needs.

Fulfillment of these purposes in an effective and economical manner requires that the maintenance concept be developed initially in conjunction with the definition of operational requirements at the inception of a program, and updated as the program develops. Primary considerations for the system maintenance concept are the levels of maintenance (i.e., organizational, intermediate, and depot) to be used in maintaining the system, and repair policy (the anticipated extent to which repair of an equipment item will be accomplished, if at all)" [Ref. 15:pp. 104-105]. The formulation of these fundamental logistic concepts and policies permits initiation of the Integrated Logistic Support Plan.

B. INTEGRATED LOGISTIC SUPPORT PLAN

"The complexity of integrating the logistic support of an item of equipment or system varies, and depends upon: the size of the program; funding available; time to complete the program; personnel and organizations associated with ILS planning; technology involved; etc. In order to reduce any complications which may arise because of these factors, it is imperative that an ILS Plan (ILSP) be developed early in the acquisition to guide the ILS Manager and other ILS participants and to ensure that the total integration of logistic design, development, and production of equipments and systems are accomplished in a timely, and effective manner. For DOD programs, a plan is required for all new and modified systems and equipment which are acquired.

An ILS Plan should contain all basic information which is necessary to undertake the procurement of an item of equipment or a system. The function of the ILSP is to identify what Integrated Logistic Support tasks will be accomplished, who will be responsible for their accomplishment, and how and when they will be accomplished. It also provides the foundation for coordinated action on the part of the Logistic Element Managers and the contractor, and documents the manner in which each of the applicable elements of logistic support is to be obtained, integrated with the other elements and sustained throughout the life cycle. Included are milestones, delivery points, names and

specific responsibilities of persons accountable for each element, basic guidance on the logistic system desired, relationships and interdependencies among the personnel, and monitoring or communications systems to pass information among participants. The ILSP should continue to undergo evolutionary changes as the program progresses to keep it current, useful, and in balance with the rest of the program.

While the format and length of the Integrated Logistic Support Plan may vary with the program, the following items should be considered and discussed as applicable:

1. The identification of each organization assisting the Integrated Logistic Support Manager in the overall planning for acquisition of logistics resources, including names or codes of assigned representatives together with a concise statement of their responsibilities.
2. The methods of communication among all participants in the ILS planning process, to ensure that all parties are fully informed of the current status of all other elements. Coordination is of prime importance to the successful achievement of Integrated Logistic Support Planning.
3. A listing of all the logistic support elements, the scope of concern with, and the planning for each at the various stages in the evolution of the system or equipment.
4. A specific approach for performing trade-offs between logistic support elements as well as between logistic support and design. Examples include repair versus throw-away and preventative versus corrective maintenance.
5. The extent to which Level of Repair Analysis (LOR) will be applied.

programming, budgeting, and funding for both the planning for ILS and subsequent acquisition of support resources.

merging of maintainability and reliability requirements into the Integrated Logistic Support planning process.

specific requirement for, and a description of, the type of the Logistic Support Analysis to be accomplished.

Identification of an appropriate management control appraisal system for evaluation of logistic support milestones.

1. Achievement of the established Navy Support date for system/equipment. The need for contractor support should be considered. Detailed requirements for a transition plan ensuring a smooth transition from contractor support to Navy Support or other transfer of logistic support responsibilities should be included where applicable.

There should be a dynamic, detailed document delineating the Program Manager's (and therefore the Logistics Manager) plan for ensuring timely, adequate, cost effective logistic support of the system/equipment" [Ref. 29:-30].

C. IIC SUPPORT ANALYSIS

Logistic Support Analysis (LSA) of an item of equipment or system is the method by which the feasibility of entering the maintenance concept is determined. The LSA also the means by which almost all of the other logistic support resources are determined.

Logistics Support Analysis is the controlling analytical effort within the ILS program. It is utilized by ILS element to provide a continual dialogue between the

designer and the logistician, which will result in the acquisition of an operationally effective, supportable system/equipment at an optimum life cycle cost. Engineering techniques are applied during an analysis to determine optimum design characteristics for minimum logistic burden of the end item and its support systems, and to identify the total support resources required by the system/equipment.

The LSA process provides for specific consideration of operator as well as maintenance requirements, and injects system support criteria into the design process earlier in the acquisition cycle. A continuous dialogue should be maintained between engineer and logistician as an inherent part of system development. This relationship maximizes possibilities for early identification of problems, thus forcing design versus support trade-off decisions before the design is finalized. LSA efforts during the program initiation phases are of special importance, having the potential for major impacts on design, systems supportability, and life cycle costs." [Ref. 29:pp. 73-74]

"The LSA is a composite of systematic actions taken to identify, define, analyze, quantify, and process logistic support requirements. The analysis evolves as the development program progresses. The number and type of iterative analysis vary according to the program schedule and complexity. As the LSA evolves, records should be maintained to provide the basis for logistic constraints,

identification of design deficiencies, and identification and development of essential logistic support resources.

Initially the LSA should develop qualitative and quantitative logistic support objectives. As the program progresses, these objectives should be refined into design parameters for use in design/cost/operational availability/capability trade-offs, risk analyses and development of logistic support capabilities. The initial effort evaluates effects of alternative hardware designs on support costs and operational readiness. Known scarcities, constraints or logistic risks will be identified, and methods for overcoming or minimizing these problems will be developed.

During design, analysis should be oriented toward assisting the designer in incorporating logistic requirements into hardware design. The goal is to create an optimum system or item of equipment that meets the specification and is most cost effective over its planned life cycle. Logistics deficiencies identified as design evolves become considerations in trade-off studies. Periodically the design and the hardware should be subjected to a formal appraisal to verify supportability features, such as accessibility and compatibility of test equipment, as specified in the contract.

As the program progresses, and designs become fixed, the LSA process concentrates on providing timely, valid data for

all areas of ILS; e.g., maintenance, provisioning, personnel and training and technical publications.

The detailed requirements for a particular LSA should be tailored by the procuring activity to suit the specific characteristics of the system/equipment. The magnitude, scope and level of detail should be consistent with the stage of development. Less than major acquisitions, including off-the-shelf items may be subjected to an LSA of appropriately reduced range and depth, but sufficient data for off-the-shelf items should be provided to allow complete identification of logistics requirements." [Ref. 29:pp. 84-85]

1. Level of Repair Analysis

"Level of Repair Analysis (LOR) is an integral part of the Logistic Support Analysis. LOR Analysis consists of non-economic and economic iterative evaluations used to establish the maintenance level at which an item will be replaced, repaired, or discarded. The economic evaluation considers cost factors pertaining to inventories, support and test equipment, space requirements, labor and training documentation.

Since repair level determination provides the basis for maintenance planning, the application of economic and non-economic analyses to specific items will be determined as early as possible. Initially, level of repair determinations may be tentatively assigned based upon engineering

studies and evaluations without consideration of economic factors. Later in the acquisition cycle, selected items should be subjected to Initial Economic LOR Analysis to isolate items which should clearly be designed for discard from those that may be designed for repair. The economic LOR process is iterative until the Final Economic LOR Analysis, which should be completed prior to provisioning for the system. The systematic procedures required to conduct an effective determination of whether a given item should be repaired or discarded, and the maintenance level at which the most cost effective repair can be accomplished, are specified in MIL-STD-1390B (Navy).

Since the design of equipment is influenced by many individuals having responsibilities in such areas as performance, reliability, maintainability, and safety, the LOR criteria applied by these individuals may not be easily converted into economic quantities. These non-economic LOR analyses should not be directly under the control of the Program Manager or the Logistics Manager. Management will thus hear arguments for repair or discard based on intangibles which will sometimes vary from decisions recommended by the economic LOR analyst. In such cases the economic analyst will normally be required to demonstrate the economic pros and cons in order that management decisions may be made with full cognizance of the cost impact of the alternative. Factors to be considered in making the

non-economic LOR recommendations include system vulnerability, mission criticality and deployment mobility." [Ref. 30:pp. 76-78]

2. Support Synthesis

"Support synthesis is the identification, description and assembly of all support approaches into alternative support systems for examination in trade-off analyses. Support synthesis should be used to provide an organized basis for the examination and selection of the support system that best provides economical, effective support of mission requirements. Each support parameter should be considered within constraints imposed by operational requirements and cost effectiveness." [Ref. 31:p. 91]

3. Trade-off Analysis

"The trade-off analysis should be a part of the continuous dialogue between support and design personnel which is an inherent part of system development. Optimum benefits are realized when this analysis identifies problems and causes design versus support trade-off decisions before the design is finalized. The nature of the trade-off models or special techniques to be used and the magnitude, scope and level of detail of the analysis should depend upon the phase of the program and the system complexity. Trade-offs early in the program should be interdisciplinary and broad in scope. Restraints will be based upon the cost, delivery schedule, and gross estimates of operational capability and

system concepts. As development progresses, trade-offs are progressively refined. Inputs become increasingly more specific and outputs influence a smaller number of related parameters. Trade-offs between support alternatives identified during support synthesis and equipment design parameters are made to provide an effective, economical support system which best satisfies system operational requirements." [Ref. 31:pp. 91-92]

4. System Impact Review

"Reviews to determine impacts of the proposed system/equipment on the existing logistic and operational systems of the Service concerned should be performed. Conversely, impacts of the proposed support system on the system/equipment under development are continuously examined throughout the LSA. Interface requirements which necessitate changes to existing systems should be identified and entered into system requirements documentation, e.g., specifications, standards and maintenance manuals. This analysis assures that the support system for the system/equipment under development is not designed as a separate entity, but that its design evolves in parallel with existing logistic systems and the development of the end item. Early system impact review accomplishes the first mating of the system performance requirements with the requirements of the Service's overall logistics system. The concepts, policies, and principles established by operations

and logistic support studies form the constraints of the support system design, and must be compatible with mission and effectiveness requirements of the system/equipment. These concepts, policies, and principles dictate allowable logistics resources and are the basis for statements of early requirements." [Ref. 31:pp. 94-95]

5. LSA Outputs

"Information developed by the LSA determines logistic support requirements. The LSA process is also a source of logistics data applied to the system design effort in the form of design constraints recommended for improving maintainability and supportability. LSA provides data for risk analyses, effectiveness studies and system trade-off studies.

The LSA provides qualitative and quantitative data used for provisioning, maintenance planning, facilities design, technical publications, support system engineering, personnel and training plans, and the Packaging, Handling, Storage and Transportability Program.

More specifically, LSA documentation identifies and describes support and test equipment; facilities requirements; personnel required by skill, type and number; spares and repair parts; and quantification of maintenance and operational support needs." [Ref. 31:p. 87]

6. Logistic Support Analysis Record

"The method of documenting the LSA is the Logistic Support Analysis Record (LSAR). The LSAR is established and maintained by the contractor as a single source of validated, integrated design-related logistics data pertaining to the acquisition program. It also includes non-design related data used in requirements determination, acquisition, and distribution of support resources. This record identifies the logistic support resources required for a specific system, equipment, component, or lower level repairable item. The LSAR integrates the various elements of ILS by considering the elements and the interfaces among them as a single entity in relation to the overall system. The LSAR insures that support is planned and that each element of logistic support is identified and verified by engineering analysis. This assurance of coordinated action is the heart of integrated logistic support." [Ref. 29:pp. 74-75]

D. MAINTENANCE PLAN

"The maintenance plan refers to the overall plan for system/equipment support, primarily from the technical requirements point of view. Specifically, it may include a description of the recommended levels of maintenance, the responsibilities for maintenance (producer versus consumer functions), the specific elements of logistic support at each level, the overall distribution and flow of support

items, and so on. Where the system maintenance concept is primarily a 'before-the-fact' input to the design process, the detailed maintenance plan is based on the results of design (i.e., a given system design configuration with supporting analysis data).

The maintenance plan, while evolving from the maintenance concept defined in the early program phases, stems from the results of the Logistic Support Analysis and is updated periodically throughout the detail design phases. It covers the initial distribution of prime equipment and the elements of support, interim producer or contractor support of the system, the procedures associated with the ongoing sustaining system support throughout the planned life cycle, the procedures for system upgrading and the installation of modification kits in the field, and so on. The maintenance plan attempts to integrate and summarize overall system support requirements." [Ref. 15:pp. 326-329]

APPENDIX B

LIST OF ACRONYMS

APML	Assistant Program Manager--Logistics
AR	Aeronautical Requirement
ASO	Aviation Supply Office
ATE	Automatic Test Equipment
BIS	Board of Inspection and Survey
BIT/BITE	Built-In Test/Built-In Test Equipment
CSE	Common Support Equipment
ILS	Integrated Logistic Support
ILSP	Integrated Logistic Support Plan
ILSMT	Integrated Logistic Support Management Team
LEM-SE	Logistic Element Manager-Support Equipment
LM-SE	Logistics Manager-Supprt Equipment
LOR	Level of Repair
LSA	Logistic Support Analysis
LSAR	Logistic Support Analysis Record
MIL STD	Military Standard
MTBF	Mean Time Between Failure
NAC	Naval Avionics Center
NAEC	Naval Air Engineering Center
NARF	Naval Air Rework Facility
NAVAIR	Naval Air Systems Command
PDA	Program Director--Air

PMA	Program Manager--Air
PMO	Program Management Office
PM--SE	Program Manager--Support Equipment
PMTC	Pacific Missile Test Center
PSE	Peculiar Support Equipment
RILSD	Resident Integrated Logistic Support Detachment
SDLM	Standard Depot Level Maintenance
SE	Support Equipment
SEAL	Safety, Engineering, and Logistics
SEPO	Support Equipment Program Officer
SPM--SE	System Program Manager--Support Equipment
TPS	Test Program Set
TRD	Test Requirement Document
UUT	Unit Under Test
VAST	Versatile Avionics Shop Test
WR	Weapon Requirement

APPENDIX C

KEY

AFP	Approval for Full Production
ALP	Approval for Limited Production
ALT	Administrative Lead Time
CDR	Critical Design Review
DCP/IPS	Decision Coordinating Paper/Integrated Program Summary
DCR	Design Certification Review
HLT	Hardware Lead Time
IOC	Initial Operational Capability
JMSNS	Justification for Major System New Start
MND	Mission Need Determination
NDCP	Navy Decision Coordinating Paper
PDR	Preliminary Design Review
PRR	Production Readiness Review
Q	Product Qualification
T, A, & F	Test, Analyze and Fix
TEMP	Test and Evaluation Master Plan

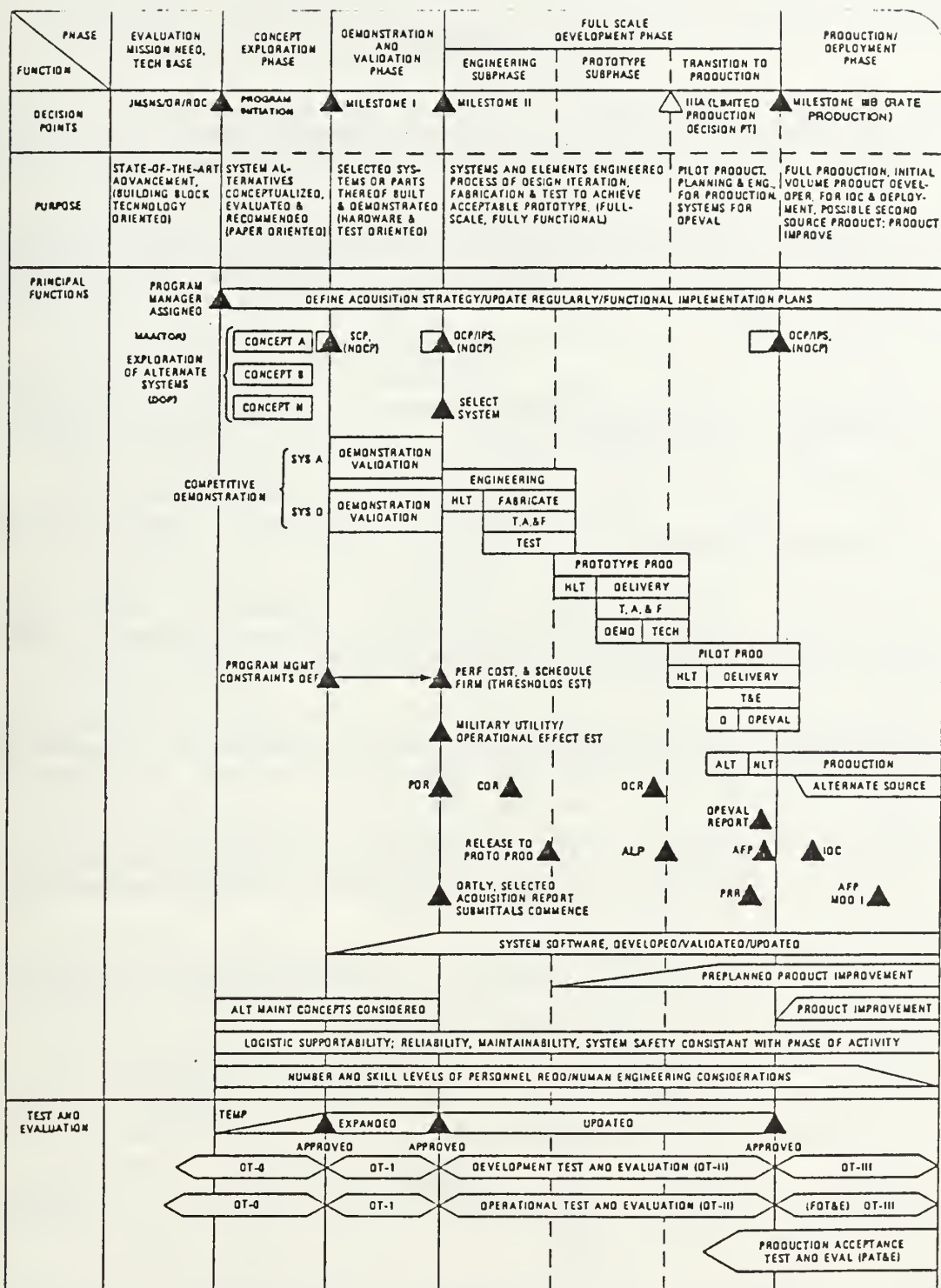


Figure 7. Summary Overview of the Acquisition Process
[Ref. 32:p. 1-18]

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